THE JOURNAL OF

THE INSTITUTION OF PRODUCTION ENGINEERS

Vol. 30, No. 11, November 1951

LORD AUSTIN PRIZE

Important Announcement

PUBLISHED BY THE INSTITUTION, 36 PORTMAN SQUARE
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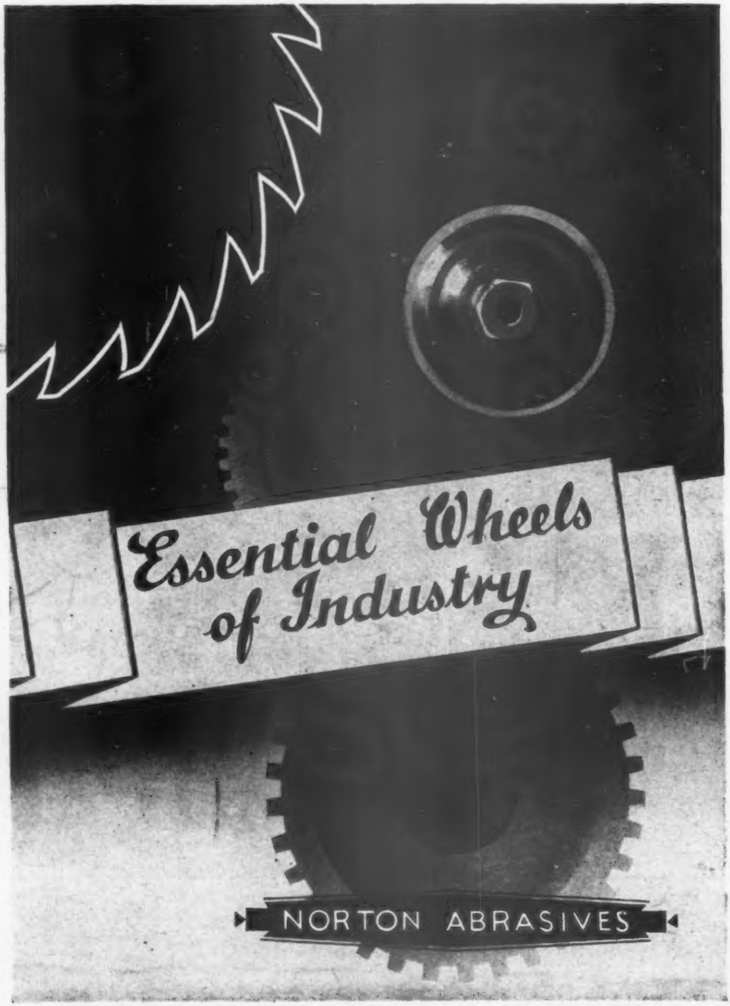
Essential Wheels of Industry
NORTON ABRASIVES


HIGH TEMPERATURES
REFRACTORIES
by
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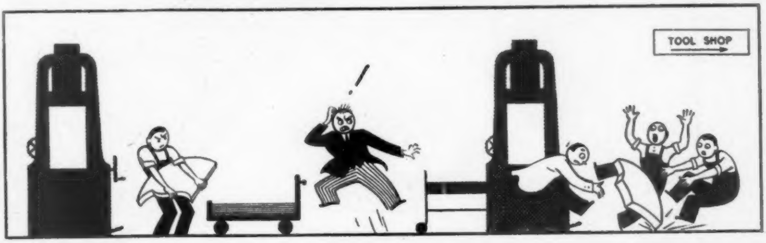
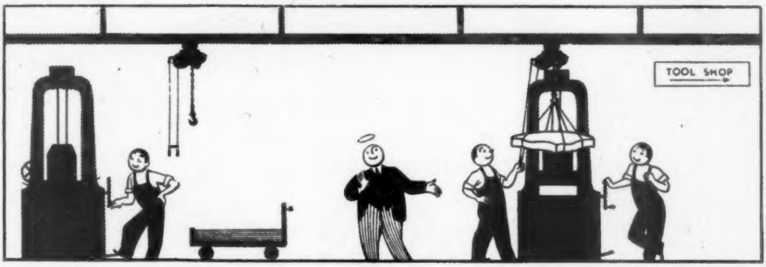
COMPANY LTD
TRAFFORD PARK
MANCHESTER

Everything happens in *some* factories



(Above) **IDLE MACHINES,** avoidable fatigue and accidents are part of the real cost of out-of-date handling. It tends to make its mark in the balance sheet when goods are heaved and humped about by hand.

(Below) **WHAT A DIFFERENCE** when lifting and shifting are *organised*, part of a smooth production flow! Nearly always it means more production, less effort, lower cost per unit.



YOU'RE PAYING FOR A MODERN HANDLING SYSTEM whether you have it or not! Replace all the humping and heaving with modern materials handling gear and you save all along the line. A well-planned installation quickly pays for itself and goes on saving time, money and effort year in year out.

Your problem is 'different'? Many of the most successful KING installations have been designed to fit a specialised need, from the sixteen miles of KING conveyors in the new Austin plant to small runway layouts.

You will find in KING booklets many useful ideas about Overhead Conveyors, Floor Conveyors, Travelling Cranes, Electric Pulley Blocks and Runways. Look into this; there's no obligation except ours—to help you speed output and cut costs.

Here is a KING Dual Conveyor on the job in a famous nut and bolt factory. Note the special tip-bins.

Refrigerators travel from Assembly to Dispatch Stores on a KING wooden slat floor conveyor in the Frigidaire factory.

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Rochester & District Sub-Section	W. G. Clements, 101, Featherby Road, Gillingham, Kent.
Sheffield	E. Levesley, The English Steel Corporation, Ltd., Sheffield.
Shrewsbury Sub-Section	B. G. Williams, " Bryn Heulog," 38, Roselyn, Harlescott, Shrewsbury.
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THE JOURNAL OF

THE INSTITUTION OF PRODUCTION ENGINEERS

Vol. 30, No. 11, November 1951

Contents

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36, PORTMAN SQUARE, LONDON, W.1

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LORD AUSTIN PRIZE, 1951

The Award

The Austin Motor Company have very generously agreed to increase the value of the Lord Austin Prize.

The prize has for twenty years been provided from a sum of £100 donated by the late Lord Austin when he was President of the Institution.

The Austin Motor Company will donate a further £100 each year for the next five years, and the value of the prize will therefore increase progressively over that period.

The prize for 1951 will consist of a miniature shield and books or instruments to the value of 10 guineas.

Past Winners

The following graduates have been awarded the prize :

1932.	L. R. Smith	1940.	G. Withington
1933.	P. C. Redwood	1941-43.	*No awards made*
1934.	L. K. Hughes	1944.	A. B. Dear and W. Johnson
1935.	J. Silver	1945.	I. McLeod
1936.	R. A. P. Misra	1946.	R. W. Deutsher
1937.	R. A. Cox	1947.	A. Short
1938.	B. M. Mason	1948.	A. V. Knight
1939.	R. W. Marson	1949.	E. R. Unitt
		1950.	G. N. Johnson

Conditions

(i) All graduates under the age of 30 years may compete for the prize.

(ii) Essays may be submitted on any subject within the field of Production Engineering. Titles of essays must be sent to the Head Office of the Institution for approval not later than 3rd December, 1951.

(iii) Essays should be not less than 2,000 words and not more than 4,000 words in length.

(iv) Completed essays must be submitted to the Head Office by 1st February, 1952.

Presentation of the Prize

The Prize will be presented to the successful Graduate at the 1952 Annual Dinner of the Institution.

INSTITUTION NOTES

November, 1951

ASSOCIATE MEMBERSHIP EXAMINATION PASS LIST — 1951

PART I

Bowden, D. G. L.
Boyle, L. T.
Calderbank, W.
Dryden, J. L.
Franks, M.
Goold, D.
Hemmett, M. J.
Houghton, L. J.
Kitson, H. E.
Leonard, J. F.
Lownes, E. J.
Martin, E. I.
Millward, E. C.
Mitchell, P. D.
Morton, J. B.
Philpot, D. F.
Pickston, D. W.
Signorini, P. A. L.
Slaughter, R. E.
Sundaram, S.
Szopinski, M.
Tosswill, R. L.
Wade, R. F.
Webb, R. M.
Wiley, D. G.
Willis, H. E.
Yeomans, R. A.

PART II

Bateman, I. L.
Boyle, L. T.
*Burnett, W.
*Calderbank, H.
Calderbank, W.
Dishman, G. A.
Edwards, E. J.
Edwards, W.
Evans, J. D.
Foster, D. J.
French, D. T.
Goold, D.
Heape, J. E.
Houghton, L. J.
Jopson, R. L.
Leonard, J. F.
Maynard, A. J. E.
Moles, P. W.
Overton, L. E.
Pendleton, D.
Philpot, D. F.
Plaster, R. E.
*Prettyman, J. A.
Reed, F. W.
Spry, W. J.
Stewart, H. C.
Sundaram, S.
Waterhouse, D.
Watts, A. H. J.
Webb, R. M.
Wiley, D. G.
Williams, R. C.

PART III

Bradley, C. I. R.
Edwards, E. J.
Fairweather, D. F.
Kean, R. A.
Morrison, R. T. W.
Overton, L. E.
Reed, F. W.
†Sanders, F. A.
Singh, D. N.
Stott, N.
Trubshaw, H.

---

* Candidates pass in Part II is subject to successful completion of English in Part I.
† Candidate's pass in Part III is subject to successful completion of specified subjects in Part II.

ANGLO-AMERICAN COUNCIL ON PRODUCTIVITY SPECIALIST TEAMS

Among the Productivity Teams which have recently been formed to visit the United States, the following include members of the Institution of Production Engineers :—

Woodworking Machinery : Mr. James C. Campbell, Associate Member, Works Manager, Thos. White & Sons, Ltd., Paisley.

Machine Tools : Mr. R. D. G. Ryder, Member, Managing Director, Thos. Ryder & Sons, Ltd., Bolton. Mr. Ryder has been appointed Leader of the Team.

Mr. R. W. Tuck, Associate Member, General Manager, C.V.A. Jigs, Moulds & Tools, Ltd.

Production Control : Mr. J. Thorpe, Member, Production Manager, Leyland Motors Ltd., Leyland.

Mr. T. W. Price, Member, Technical Production Director, E.M.I. Ltd.

Mr. F. O. Gloss, Associate Member, Deputy Works Superintendent, The British Oxygen Co. Ltd.

NEWS OF MEMBERS

Mr. G. W. Butler, Associate Member, is now an Assistant Lecturer at the County Technical College, Wednesbury.

Mr. G. T. Chawner, Associate Member, is taking up an appointment as Lecturer in Engineering Subjects at the Witwatersrand Technical College, Johannesburg.

Mr. G. Comer, Associate Member, is now Assistant Chief Designer with Omes Ltd., Barnes.

Mr. H. E. Dales, Associate Member, has joined Associated Industrial Consultants, Ltd., London, as a Resident Consultant.

Mr. C. Ellis, Associate Member, of E. Pryor & Son Ltd., Sheffield, is now Chief Engineer.

Mr. E. F. Gilberthorpe, Member, has been appointed Assistant General Manager of S. M. Wilmot & Co. Ltd., Bristol.

Mr. H. V. Lustig, Associate Member, has been appointed Production Controller with British Acoustic Films Ltd., London.

Mr. G. S. Mutch, Associate Member, has been appointed Principal Teacher of Engineering at the Dundee Trades College.

Mr A. S. Nagi, M.Sc., Associate, of B. N. Elias & Co., Calcutta, is in England on a short industrial visit until January, 1952.

Mr. G. B. Parsons, Associate Member, is now a full-time Assistant Teacher for Engineering Subjects with the City of Nottingham Education Committee at the People's College of Further Education.

Mr. D. A. Pearson, Associate Member, has joined the staff of W. T. Glover & Co. Ltd., Manchester, as Personal Assistant to the General Manager.

Mr. J. W. L. Russell, Associate Member, has taken up the appointment of Works Engineer with the National Carbon Co. (India) Ltd., Calcutta.

Lt. Col. J. H. Snelson, Member, is now O.C. No. 11 Vehicle Depot Workshops, Ashchurch.

Mr. John C. N. Thompson, Associate Member, is employed as a Technical Engineer with Renold & Coventry Chain Co. Ltd., Manchester.

Mr. H. H. Valberg, Associate Member, is now Foundry Manager with Platt Bros. Ltd., Oldham.

Mr. G. N. Venn, B.Sc.(Eng.), Associate Member, is now with the National Research Development Corporation as Assistant Technical Manager in charge of Engineering Projects.

Mr. W. R. Gaudion, Graduate, has been promoted to Works Manager with Henry Broadbent Ltd., Sowerby Bridge.

Mr. J. J. A. Hall, Graduate, has taken up a post as Technical Representative in the Bombay office of Heatly & Gresham Ltd.

Mr. J. S. Langford, Graduate, has been appointed Manager of the Stainless Division, Talbot-Stead Tube Co., Walsall.

Mr. A. T. H. Selby, Graduate, is now a Planning Engineer with Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton.

Mr. H. A. Turner, Graduate, is now a Machine Tool Designer with Modern Tool Works, Toronto.

Mr. N. H. Ward, Graduate, has transferred to the International Combustion Limited's Associate Company, Ipscol Ltd., Southampton, as Production Manager at the Shipyard Estate.

BRITISH STANDARDS

The following Standards have recently been issued, and may be obtained, post free, at the prices stated from the British Standards Institution, 24-28, Victoria Street, Westminster, London, S.W.1.

132 : 1951 Steam Turbines (2/-)

1737 : 1951 Jointing Materials and Compounds for Water, Town Gas, and Low-Pressure Steam Installations (5/-)

1761 : 1951 Single Bucket Excavators (6/-)

1768 : 1951 Unified Precision Hexagon Bolts, Screws, Nuts (UNC and UNF Threads) and Plain Washers—Normal Series (3/-).

1769 : 1951 Unified Black Hexagon Bolts, Screws, Nuts (UNC and UNF Threads) and Plain Washers—Heavy Series (2/6).

1770 : 1951 Pipe Flanges for use on Internal Combustion Engines and Installations (2/-).

HAZLETON MEMORIAL LIBRARY

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when borrowing books.

ABSTRACTS

347.7 COMMERCIAL LAW

"Employer's Liability at Common Law" by John H. Munkman, Ll.B. *Butterworth & Co. Ltd., London.* 339 *pages.* 1950. 21/-.

Mr. Munkman's book on the Law of Tort as applied to Employer's Liability is distinguished from the usual text books on the subject by its emphasis on the application of the Law of Tort not only to industry as a whole, but to particular industries, e.g. there are chapters on Shipbuilding Yards and Docks, Building and Engineering Operations, Electricity, Coal-mines, Metalliferous Mines and Quarries, Railways and Private Sidings.

Whilst the book is, no doubt, primarily for practising Lawyers and Insurance and Trade Union Officials dealing with litigation, its chapters on the Historical Development of Employer's Liability Law, Employer's Personal Negligence, and Employer's Vicarious Liability will also be found to be of interest to Managers and Industrial Executives.

There are also chapters dealing with various aspects of Statutory Factories Legislation, but emphasis is always placed on the Common Law interpretations relating to such Statutes.

Throughout the book, Mr. Munkman refers to a large number of cases for illustrative purposes, and his table of cases at the beginning of the book, cross referenced to cover most of the better known Law Reports, will be found most useful. Knowledge of the Law in general, and particularly of Statute Law as applied to Industry appear to be essential prerequisites for deriving the fullest benefit from this book.

159.9226 MENTAL CHARACTERISTICS AS INFLUENCED BY AGE

Welford, A. T., *and others.* **"Skill and Age : an Experimental Approach."** *London, Oxford University Press for Nuffield Foundation.* 1951. 161 *pages.* 8/6.

The work lays foundations of investigation into the nature of abilities and disabilities which increase with age, with bearing towards work for which older people are suited and methods of re-training. It declares that while dealing mostly with abilities apparently diminishing with age, the way is opened for positive study of cases in which age brings improved performance. While disclaiming entire finality, its steps are positive.

Physical structure is subject to successive changes from birth and viewed as a machine, rises to peak efficiency in the twenties, thereafter declining, causing individuals to use compensating mechanisms in maintaining performance.

Environment tends to narrow the range of what a man is " likely " to do, causing him to draw upon experience in dealing with a current problem and encouraging new resourcefulness against future situations. Pattern of action in dealing with stimuli would be laid down in advance, becoming better formed, then when the stimulus arrives it triggers-off a preformed response.

Skill is examined with the acceptor and effector aspects of organisation. Conclusions make apparent that age finds increasing difficulty in organising data, requiring more stimulus or time. The cause of lessened performance may be located in acceptor and not the dependent effector mechanisms.

669. METALLURGY

Chalmers Bruce. **" Structure and Mechanical Properties of Metals."** *Lond., Chapman & Hall,* 1951. 132 *pages. Diagrams.*

(Monographs on metallic materials, published under the authority of the Royal Aeronautical Society; vol. 2.)

This is the second volume in the series of Monographs issued under the authority of the Royal Aeronautical Society. It has been written primarily for the reader who, having a general elementary knowledge of physics and chemistry, is anxious to know more about the structure of metals and alloys and the effects of deformation and heat treatment on those structures. Such information is given without reference to mathematical considerations and is followed by a brief account of the methods of examining and determining structure. The last chapter covers mechanical properties and their dependence on structure and completes a volume which is in no sense a reference book, but will be of value to all students of metallurgy.

OTHER ADDITIONS

159.9 PSYCHOLOGY

Baumgarten, Franziska. **" Pyschology of human relations in industry,"** tr. by E. D. Nisbet. *Lond., Pitman.* 1950. 205 *pages.*

331.055 FATIGUE STUDY

Gilbreth, Frank B., and Gilbreth, Lillian M. **" Fatigue study."** *Lond., Routledge.* 1919 175 *pages. Illustrated.* (Efficiency Books.)

331.2 WAGES; PAY

Jones, Philip W. **" Practical job evaluation : the applications of wage determination to wage structures."** *N.Y., Wiley. Lond. Chapman & Hall,* 1948. 304 *pages.*

510. MATHEMATICS

Toft, Louis. **" Definitions and formulae for students—practical mathematics."** 3rd ed. *Lond., Pitman.* 1951. 38 *pages.* 1/6.

535.8 OPTICAL INSTRUMENTS

Williams, W. Ewart. **" Applications of interferometry."** 4th ed. *Lond., Methuen. N.Y., Wiley.* 1950. 104 *pages. Diagrams.* (Methuen's monographs on physical subjects.)

614.8 PREVENTION OF ACCIDENTS ; SAFETY MEASURES

MacMillan, C. M. **" Foremanship and safety."** *N.Y., Wiley. Lond., Chapman & Hall.* 1943. 101 *pages. Illustrated.*

620.1 STRENGTH OF MATERIALS

Woldman, Norman E. **" Materials engineering of metal products."** *N.Y., Reinhold Pub. Corp.* 1949. 583 *pages. Illustrated. Diagrams.*

620.942 ENGINEERING—ENGLAND—HISTORY

Hollowood, Bernard. **" Cornish Engineers."** illustrated by T. Cuneo. *Camborne, Holman Bros. Ltd.* 1951. 95 *pages. Illustrated. Facsimiles. Maps.* (History of Holman Bros. Ltd., Camborne, Cornwall.)

621.0052 AUTOMATIC CONTROLS

Ashley, J. W. **"Automatic control of industrial plant and processes."** *Manchester, Emmott & Co. Ltd.* 1950. 65 *pages. Diagrams.* (Mechanical World Monographs.)

Porter, A. **"Introduction to servomechanisms."** *Lond., Methuen. N.Y., Wiley.* 1950. 154 *pages. Diagrams.* (Methuen's monographs on physical subjects.)

621.74 FOUNDRY WORK

Institute of British Foundrymen, *Manchester.* **"Proceedings."** Vol. 43, 1950. *Manchester, The Institute.* 1951. 250 *pages.* 158 *Illustrations. Diagrams.*

621.791 WELDING

Burgess, C. O. **"Welding, joining and cutting of gray iron."** *Cleveland, Gray Iron Founders' Society.* 1951. 40 *pages. Illustrated.*

Tibbenham, Lewis John. **"Welding of cast iron by the oxyacetylene process."** 2nd ed. *Lond., Pitman.* 1945. 120 *pages. Illustrated. Diagrams.*

621.7913 SOLDERING ; BRAZING

Lewis, W. R. **"Notes on soldering."** *Greenford, Tin Research Institute.* 1948. 88 *pages. Illustrated. Diagrams.*

621.793 METAL COATING

Hoare, W. E. **"Hot-tinning—practical instructions."** *Greenford, Tin Research Institute.* 1948. 112 *pages. Illustrated. Diagrams.*

621.795 SURFACE PROCESSES ; FINISHING

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658. INDUSTRIAL ORGANIZATION ; MANAGEMENT

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658.23 FACTORY LAYOUT ; PLANNING

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662.6 FUELS ; INDUSTRIAL HEATING

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JOURNAL BINDERS Members are reminded that binding cases for the Journal are obtainable from Head Office, price 7/6 each post free. The cases, each of which will hold 12 issues of the Journal, are made of stiff board covered with imitation leather cloth, with gilt lettering on the spine.

CHANGE OF ADDRESS It would be of great assistance to Head Office if members would ensure that the business addresses contained in their records were up-to-date, and would notify Head Office as soon as possible of any change of appointment.

RESEARCH PUBLICATIONS A number of copies of the following Research publications are still available to members, at the prices stated :

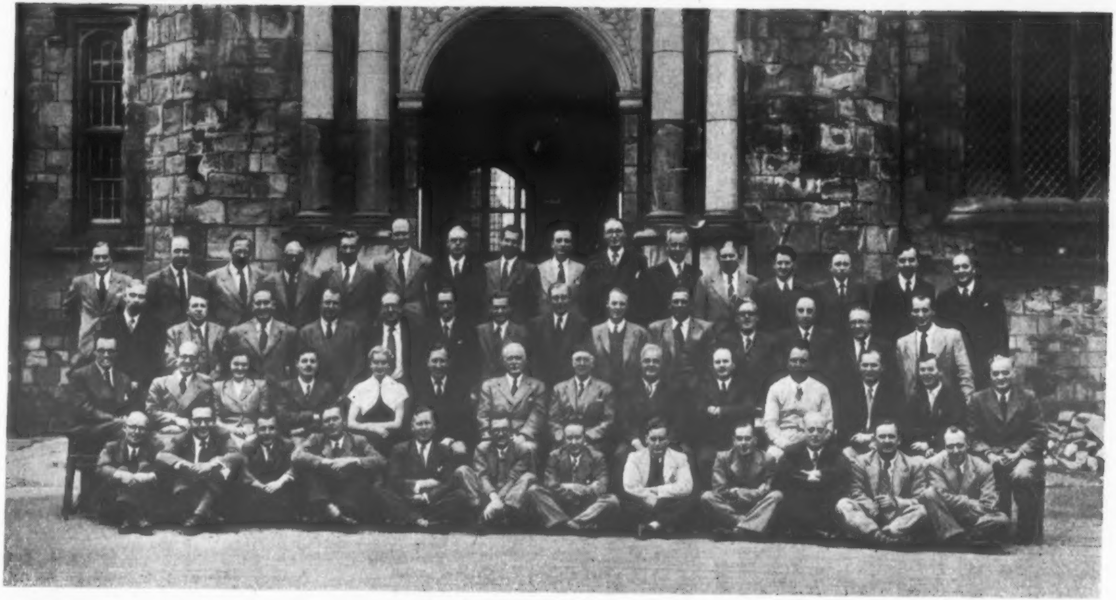
Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research & Development	10/6
Practical Drilling Tests	21/-
Test Charts for Machine Tools, Parts 3 and 4	5/6 each

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge", Melton Mowbray, Leics.

ISSUE OF JOURNAL Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

HARROGATE CONFERENCE—OCTOBER JOURNAL Mr. H. C. Cook, Member, who took part in the discussion following Mr. R. B. Wilkinson's Paper presented at the Harrogate Conference, asks us to point out that on page 657 he is reported as having said "Production was subordinate to the systems employed," whereas his actual remark was "Production should *not* be subordinate to the systems employed."



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SUMMER SCHOOL, 1951

SECOND ANNUAL SUMMER SCHOOL OF PRODUCTION ENGINEERING

UNIVERSITY COLLEGE, DURHAM

29th August/2nd September, 1951.

THE Second Annual Summer School of Production Engineering was held by the Institution at University College, Durham. The historic Castle and Cathedral formed a really magnificent setting for the work of the School, and a number of members were fortunate enough to be shown round both these lovely buildings by the Censor of the College, Dr. Gregory.

Meals were taken in the Great Hall of the Castle, and many of those who attended had rooms either in the main part of the Castle building or in the keep.

The theme for this year's School was stated simply in the programme as, " Developments in the Study of Production Engineering," and the programme was prepared and developed with the object of surveying recent developments in the study of production technology and management, to see how far these developments should be reflected in courses in Production Engineering.

Three Lectures were given, on " Standards of Industrial Performance," " Product Design," and " Materials Handling." These lectures were given at full sessions of the School, after which members discussed the subjects in their groups and returned at later sessions to report to and ask questions of the lecturer, through their selected rapporteurs.

In addition to these activities a series of three distinguished after-dinner addresses was given on " Science and Industry," " The Armed Services and Industry " and " Education and Industry."

Opening Address by the President

Major-General K. C. APPLEYARD, C.B.E., T.D., D.L., J.P.

The President commenced his address of welcome by expressing the Institution's gratitude to the Master of University College for permitting the Summer School to be held in such magnificent and congenial surroundings, and he introduced Dr. Gregory, the Censor of the College, who, deputising for the Master, said that he hoped that the ancient surroundings would prove as congenial to those practising one of the most recent of the applied sciences as they were to those engaged in " the more archaic forms of learning."

General Appleyard continued by expressing the very real pleasure which it gave him to preside at an Institution Summer School at Durham, in a county which had been his home since he became a Production Engineer 37 years ago.

INDUSTRIAL ACTIVITIES

He referred to the great industrial activities of the North-East Coast—coal mining, locomotive building, shipbuilding and the electrical and chemical industries ; yet Durham itself, in the heart of a busy county, was he said a peaceful city of history and tradition. It had, however, not always been a place of peace, for through nearly nine centuries it had been the bastion of the North—the place from which the Prince Bishops of Durham, Counts Palatine, had stubbornly resisted by force of arms all invaders from the Conqueror to the Scots.

General Appleyard expressed the hope that everyone who had come to Durham for the Summer School would sit for a while and consider the cathedral, which was started in 1093 and finished in the main, by 1140. He wondered whether, with all our modern resources, we could create such a mighty and beautiful work of stone to-day.

After referring to the problems of the present century, the President concluded by saying that he was certain that the inspiration of the past could guide all of us in our consideration of the problems of the future, and he wished all members of the School a successful and enjoyable time at Durham.

Survey of the School's Programme

by T. B. WORTH,
Education Officer.

Mr. Worth opened his review by stressing the need for an appreciation of the background against which studies in Production Engineering operated at the present time, as this would help to explain why the particular subjects had been chosen, to relate them to the many other aspects of Production Engineering, and to define modern practice.

Production Engineering as a specialised study and practice grew, he said, from the application of scientific methods of manufacture in organisations whose products consisted in the main of more or less standard parts. Such developments had been closely associated with engineering and allied industries, but it was well recognised that benefits accrued from the application of Production Engineering principles to all forms of manufacture.

Mr. Worth continued by saying that although it was right that due regard should be paid to what might be called the traditional

aspects, such as manufacturing plant and processes, modern circumstances made it necessary for the focus to be placed on others, rather less easy of definition and indirect in comparison, but vital to modern methods of manufacture. In the first place Production Engineering had to be studied with due regard to close and effective co-operation between the technical and administrative functions, thus bringing in the human factor, and secondly it was being recognised that certain functions of Production Engineering formed a continuous thread or binding agent throughout the manufacturing process.

The programme reflected these developments and the first lecture on **"Standards of Industrial Performance"** would give an opportunity for a close survey of the essential links between the technical and management fields.

In the case of **"Product Design,"** the problem was one of approach rather than method, since problems of standardisation and simplification, whilst relatively easy to define, involved difficulties both to management and engineering.

"Materials Handling" was now recognised as a most important aspect of the planning and co-ordination of production, although little attention had been paid to it until recently by the educational establishments of the country.

Mr. Worth concluded by drawing attention to two of the important objectives of the School, namely Study of the Subjects and Applications of the Subjects in industry, the armed services and colleges, and referred to the three evening addresses, which he said would be inspirational in character.

"Standards of Industrial Performance"

by WALTER C. PUCKEY,
Chairman of Council.

Major-General Appleyard was in the chair and introduced Mr. Puckey, who started his paper by stating that there were two basic requirements which he would discuss—" Setting the Standard " and " Checking the Performance " whilst, in addition, since the School was considering recent developments, he would consider one further important requirement, namely " Presenting the Information."

SETTING THE STANDARD

Mr. Puckey questioned the number of standards attempted, and said that an essential preliminary to the setting of a standard was the ability to measure. He suggested that the problems involved in measuring

activities, which were not at present very closely defined, required more detailed investigation, and then went on to consider the maximum performance desired and the time element.

He emphasised the need to avoid setting standards too low and regarding them as permanent. Great skill lay in advancing the standard in the right amount at the right time.

He also stressed the fact that the standard must contain a time element, since no programme was worthwhile unless it was linked up with the time required to achieve it. It was in the time taken that so many had fallen down so badly since the war, and he suggested that the development of a competitive spirit would help to correct this.

CHECKING THE PERFORMANCE

In checking performance the important thing was to ask the right question at the right time, and as an example of this technique members of the School were referred to the appendices in the Memoirs of Mr. Winston Churchill.

Five further points were discussed briefly under this heading—approval of performance standards as quickly as possible, publication of the standards promptly and in sufficient time for the programme to be achieved, allocation of precise personal responsibilities, encouragement of the competitive spirit among all concerned, and a ruling that major standards can be altered only on the highest authority.

PRESENTING THE INFORMATION

In dealing with the final requirement Mr. Puckey referred to the growth of the Personnel function, and the importance of regarding man as an individual. In presenting information it was vital to ensure that knowledge and understanding was brought down to individual level, for if Managers did not succeed in doing this others would.

Mr. Puckey ended by making the point that in industry it was becoming ever more important that young men should be encouraged to take decisions and to display initiative ; he considered that those particularly concerned with the education of young Production Engineers might well view this as one of the most important aspects to study and to foster. The Institution itself owed its strength, he said, to its qualities of initiative, based upon personal enthusiasm.

DISCUSSION

The lecture groups subsequently considered points left with them by Mr. Puckey, and later returned to make comments to or ask further questions of him. Among the aspects which received special consideration were—the number of standards of performance which should be employed,

the setting of " maximum performance," modification of standards, competitive spirit as an aid to better performance, the " time element," the presentation of information incentives and worker-management relations.

"Science and Industry"

by Dr. F. A. FREETH, O.B.E., F.R.S.,
(Imperial Chemical Industries, Ltd.).

The President, who again was in the Chair for the evening address, welcomed, on behalf of the School, the Mayor of Durham, the Recorder and Clerk to the County Council, and other distinguished guests before introducing Dr. Freeth.

Dr. Freeth commenced his address by saying that he proposed to reverse the order of the title given on the programme, and talk of " Industry and Science "—he wanted to put himself into the position of a Production Engineer, and then see if he could from his experience offer any help or advice which might assist Production Engineers in their work.

In the course of a most entertaining and invigorating address he showed the need, largely by means of a series of fascinating anecdotes, for the Production Engineer to be a " whole " man, and emphasised the vast amount of knowledge and experience of people and affairs which can be gained by travel and by the investigation of philosophies, sciences and activities outside the somewhat narrow confines of one's daily work.

Finally he stressed the immense value of studying emotional difficulties and problems, and the need to consider always the reactions and aspirations of other people, on whose co-operation the success of one's work largely depended.

"Product Design"

by J. B. JAY,
(Chief Designer, Hymatic Engineering Co. Ltd.).

Professor T. U. Matthew, M.Sc., was in the Chair and introduced the lecturer.

PRODUCT DESIGN

Mr. Jay opened his lecture by stating that it was doubtful whether advances in the study of Product Design matched those of research and production. It was not an exact science but the average level of design ability demanded some process to check the design as it proceeded, and critical analysis should be made from the start.

Product Design could be considered as involving function, cost

and æsthetics, but he thought that questions of appearance, packaging, sales appeal and others should be considered after or in conjunction with sound product design.

Further, it was essential that in all these problems, the design department and production department should co-operate to the full, and particularly on the question of costs.

Mr. Jay explained that he was associated with a firm whose designs were usually based on initial batches of between 50 and 1000 and gave the origins of new designs as :—

(1) An entirely new product, resulting from a scientific advance, as in gas turbines and rocket motors.

(2) A new product for a new purpose, such as tank landing craft and flail tanks.

(3) A development from an existing design to extend use or reliability.

(4) Redesign for cost reductions, quantity production and simplification.

(5) Redesign for better appearance and increased sales potential.

He stated that it was important for management to tell designers the reason for a design requirement, the circumstances attending the product and its marketing.

In many instances, customers had only a vague idea of what they required and conferences between customers and designers were all important in defining the time basis of a design. After agreement on specification, critical analysis must be applied to solve problems of plant availability, finance, research and development.

LIAISON BETWEEN DESIGN AND PRODUCTION Mr. Jay thought that the practice of settling all design problems through a third party such as a technical salesman was not the best way of reaching a design solution quickly. He posed a series of questions which the designer must answer and stressed the importance of feeding designers with essential information concerning external decisions. The designer should be interested in delivery dates and other relevant factors. He also emphasised the importance of good relations between the design function and the production function, and said that although good organisation tended to separate the experimental section from design, they should be checked for standardisation and simplification, and the market standard of the design should be constantly borne in mind.

Concerning organisation, Mr. Jay thought that the modern trend was towards a simple office embracing both project design and Production Engineering, so that the engineer who originated a design had some authority over the detailed drawing which went into quantity production. Whichever way the detailing was

carried out, however, it was essential that up-to-date information was available to the draughtsman and designer regarding the relative costs of materials, processes and production methods, so that all concerned could apply the processes of critical analysis to each detail.

Reference was made to the new British Standard on Drawing Office Practice (B.S.308) and to other standards which might be applied. Mr. Jay then suggested that, in addition to the frequent discussions between the Design and Production Engineers, some document should be issued with the detail drawings, calling attention to the methods of production visualised by the draughtsman when he decided on his tolerances and his methods of dimensioning. The document would be explanatory and not mandatory.

The economics of design modification were then discussed, and a warning given on the need to ensure that modifications, however desirable, could be really justified economically.

Mr. Jay concluded by illustrating, by means of a case history, the application of critical analysis of the design and co-operation between the design and the production departments.

The Chairman thanked Mr. Jay for a most stimulating lecture and left the discussion groups with five main points for consideration.

DISCUSSION

On the question of the training of designers it was considered that a practical knowledge of workshop practice and processes, plant and materials and their machinability was essential. It was thought that standardisation of parts and of radii to be cut by machine processes was desirable, whilst standardisation of gauges and measuring instruments could be achieved by careful design, and close co-ordination between the drawing office and inspection would tend to achieve standardisation of quality.

Important aspects of simplification were discussed from the standpoint of costs and suggestions were made as to the introduction of modifications.

Mr. Jay replied to points and summed up at the close of the discussion in which he was assisted by Mr. Haerle, the Technical Manager of Hymatic Engineering Company, who dealt with questions of co-ordination in the fields of design, research and development.

"The Armed Services and Industry"

by Major-General S. W. JOSLIN, C.B., C.B.E., M.A.,

(Director of Mechanical Engineering, War Office).

A number of prominent local industrialists were present for this address, and the President, who was in the Chair, introduced General Joslin to the School.

In a broad survey of the relationship between the Armed Services and Industry, General Joslin considered ways in which they might help each other in their important jobs. He said that so far as his own Corps and the Institution were concerned, he was happy to say that co-operation had for a number of years been operating most fruitfully.

The material needs of the armed services could be summarised briefly as quality, reliability and punctuality. The question of punctuality led to consideration of production forecasts, and at this stage General Joslin described the function of the Ministry of Supply in the design and development, and inspection of equipment for the Army.

In discussing human relationships, General Joslin outlined the technical training given at the Army Apprentices' School and claimed that the services gave splendid training in leadership to all who showed their ability to profit from it.

Finally the General outlined the important national issues which influenced both industry and the armed services, and pointed to the ever growing demand by the services for highly skilled technicians.

"Materials Handling"

by W. J. DIMMOCK,

(Works Manager, Hoover Ltd., Perivale)

Mr. B. H. Dyson, in the Chair, introduced Mr. Dimmock and mentioned the work which he had recently carried out as Secretary of the Materials Handling Productivity Team.

Mr. Dimmock opened his lecture by referring specifically to Recommendation No. 8 in the report of the Productivity Team, which stressed the need for additional teaching facilities in the principles of materials handling, and the importance of an understanding and appreciation of this vital subject by future executives.

He then went on to define materials handling under three main headings :

1. Methods of receiving incoming materials, handling and distributing to stores or manufacturing departments.
2. Methods of handling materials through successive stages of processing and manufacturing.
3. Handling techniques in the packing, storing and despatching of products.

Materials handling operations generally, in the engineering industry, greatly outnumbered direct manufacturing or process operations, and the cost of handling was often a major item. Handling had to receive the same detailed consideration from the Production Engineer at the planning stage as, for instance, machine design and process technology. Mr. Dimmock continued by

quoting the recent report of the Chairman of a large company who stressed the importance of compact factory layout, economy of factory space and mechanisation of handling operations. Work in progress was, he said, the "graveyard of profits," and with ever increasing materials costs efficient handling became more vitally necessary.

RATIONALISATION

Before mechanisation of handling took place, however, it was usually necessary to rationalise existing methods and systems. The simplification of handling and movement could make a valuable contribution to the reduction of costs, and this strengthened the emphasis on the use of flow charts.

Too much concentration on the number of men who might be released for other work should be avoided, Mr. Dimmock went on; such an outlook would require modification if it retarded the application of improved methods. Advantages such as the reduction of turn-round time for vehicles, more effective use of warehouse and dock space, and an increase in the volume of turnover were too often overlooked.

Mr. Dimmock then considered the part which colleges, professional institutions, the Ministry of Education and trade associations could play in stimulating interest in the subject, and contrasted our efforts in the past with the considerable attention which had been given to the subject in the U.S.A.

After examining in detail advantages secured through improved materials handling, Mr. Dimmock concluded by showing a short film dealing with materials handling techniques in receiving, warehousing and despatch departments of a manufacturing unit.

Mr. T. B. Worth then showed a short film-strip on the principles of materials handling.

DISCUSSION

During the discussion a proposal was made for a regional advisory service which would "spread the gospel" of materials handling. Other groups stressed the need to inform workers before installing new handling devices, the importance of suggestion schemes, the value of a national survey of handling methods, and the importance of preparing for management a detailed statement of the savings to be achieved by efficient materials handling.

Open Forum

Mr. W. E. Park, Chairman of the Institution's Education Committee, took the Chair for the open forum and had with him on the platform the Education Officer and the Summer School Secretary, Mr. G. E. Knight.

The Chairman said that many of the recommendations made at the 1950 Summer School had been of value in the planning of the 1951 School, and he assured members that their recommendations and views would receive most careful consideration from the Education Committee.

Among suggestions made by the groups were the need for stronger emphasis on the educational aspects of the theme, and the opportunities for further discussion which would result from more adequate common room facilities. All groups expressed their satisfaction with the general arrangements for the School.

"Education and Industry"

by NOEL F. HALL, M.A.,

(Principal, Administrative Staff College).

The President said how lucky they were to have the opportunity of listening to Mr. Hall, whose work at the Administrative Staff College was proving to be of the greatest value to industry, the armed services and the Civil Service.

After outlining some of his experiences as a lecturer at London University and impressions gained during a two-year research fellowship in the United States, Mr Hall stated the differences between the duties which education and industry respectively had to discharge.

The professional educator's first duty was to accept knowledge for its own sake, to advance knowledge in his own field wherever his search for truth might lead him, and not only to advance knowledge but to ensure its continuing growth and advancement. In his relations with his pupils he knew that it was in the fully emancipated talents of those pupils that the future progress of knowledge and human welfare would depend.

The industrialist in his working hours needed a different attitude towards both knowledge and the individual, and had to view both in relation to their end products. Nevertheless with all the differences in his basic approach to the individual, the professional man, and not least the professional Production Engineer, must be inspired by a truly vocational attitude so that he could explain his knowledge to, and develop, lesser men.

Mr. Hall concluded his address by considering the status of the Profession, and the qualifications and responsibilities of the professional man.

The President expressed the gratitude of all members of the School to Mr. Hall for his fine address, and before closing the School he asked Dr. Gregory to thank the Master on their behalf for all that had been done to make it the success it had been.

TRACER CONTROLLED MACHINE TOOLS

by P. K. EISNER, Grad.I.Prod.E.

Presented to the Manchester Graduate Section of the Institution, 19th January, 1951.

AS the subject of tracer controls applied to machine tools and treated as a separate field of study is relatively new, it can be legitimately assumed that there are many Production Engineers who are not fully aware of the possibilities the various devices offer. We shall therefore begin with some introductory remarks with regard to the ramifications.

For the purposes of this paper, a tracer-controlled machine or mechanism may be considered as any tool reproducing a non-geometric or irregular contour on the component being machined, without any further manipulative action taking place on the part of the operator once machining has commenced.

This definition is necessarily very inadequate, and it will be noted at once that certain types of automatic machinery could be included under this heading although, of course, automatic or special purpose machines are not generally considered as forming part of the subject under discussion. Nevertheless, it is worth noting at this stage that cams and similar devices do, in fact, represent to some extent a type of tracer control which may be described as being of a mechanical nature. Thus the movements of the tool slide, indexing of the turret, advance of dieheads, etc., on an automatic lathe are strictly controlled by a series of cams. This method of control, however, is sufficiently well known to most engineers to be excluded for the present.

Whilst the generation of geometric contours such as cylinders, cones, flat surfaces, cubes, angles, etc., within given limits of accuracy by the normal machining methods presents comparatively little difficulty, the reproduction of irregular forms is considerably more difficult, and some means has generally to be devised to guide the cutting tool in such a way as to arrive at the desired shape in the end.

The most obvious way of achieving this object is, of course, to employ a highly skilled operator who would be able to machine such an irregular shape on a standard machine tool, in much the same way as a tool-maker produces a complicated combination press tool with the aid of a relatively small number of fairly standard machines. But this method is costly and slow, and it therefore

becomes necessary to devise machines which will make some of the operations involved in producing irregular contours, if not entirely automatic, at least semi-automatic, thus helping in speeding up production both in the tool room and the general machine shop.

This paper is an attempt to examine some of the methods available to the engineer in building such equipment, and we shall consider the underlying principles first and look at some of the ways these have been applied to actual manufacturing operations, later.

MECHANICAL TYPES

All tracer controls, whether mechanically operated or otherwise, employ some type of " master," which may or may not correspond to the exact shape to which the component has to be machined. In mechanical types of following devices, the pressure exerted by the cutter on the material being machined depends largely on the physical strength of the master itself. The material from which it is made is therefore in practically all cases hardened steel.

(i) In some types of mechanical tracers, a roller following a cam provides the direction motion to the portion of the machine which is to be controlled, but sometimes an attempt is made to reduce the actual force required to lift and lower heavy parts of machinery by means of systems of levers. This increases the mechanical advantage of the mechanism to some extent, but for most applications the drawbacks of this particular type of appliance are overwhelming. It will be obvious that errors of the master are magnified on the job and as contact between follower and master is generally maintained by friction only, chatter marks can give considerable trouble. The system is altogether simple but crude, and we shall not consider it in any detail here. It is generally used in the case of relatively heavy machining operations only where the limits of accuracy are not critical.

(ii) A more specialised application of the lever principle is one making use of pantographs in its various forms. The principle of the pantograph is that it enables a given path to be reproduced to an enlarged or reduced scale, the individual members of the mechanism being constrained in such a way that a movement of the tracer point will cause the copying point to trace out either an exact image or a mirror image of this, according to where the fixed point is located. In the example shown (Fig. 1) a mirror image would obviously be obtained. It will also be apparent that by altering the ratio of the links, different magnifications or reductions can be obtained.

Pantographs have been extensively used in engineering in the past—Watt's straight line motion is a well-known example—but their application to machine tools is much more recent, and some typical examples will be discussed later.

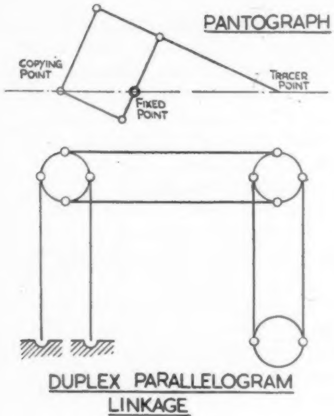
It may also be useful to mention at this stage the duplex parallelogram linkage shown in the lower portion of Fig. 1, of which a well-known application can be found in the ordinary draughting machine. The object of this linkage is to constrain the tracer point to move in a fixed angular relationship with the copying point, which in the case of the draughting machine is also identical with the fixed point, i.e., the drawingboard.

These two linkages have in some cases been combined, and an example of a machine where this has been done will be shown later. Fig. 2 however shows diagrammatically the arrangements of an early German machine used for form grinding irregular contours. A drawing, 50 times full size, is pinned on the drawingboard shown in the bottom left hand corner, and the cross slides of the machine adjusted until the grinding wheel edge is seen at the centre of the cross lines of the microscope. The tracer operating the pantograph is then moved by a small amount along the contour and the process repeated. Patience and skill are required to obtain a really smooth profile.

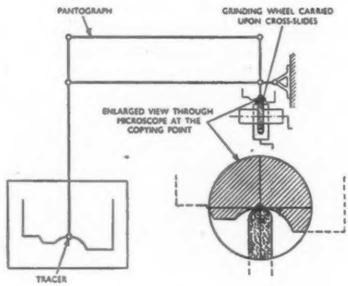
(iii) There are some machines which cannot properly be included in either of the two first mentioned groups, although their copying device is based on a mechanical principle. For lack of a better definition they may be called the "template and roller type." The idea behind most of these machines is that there is some kind of master, usually a flat template, around which the path of the cutter is guided. Hand pressure only is used in most cases to maintain contact between the cutter and the template, which may be mounted side by side with the component being machined or directly above or below it. Fig. 3 shows the two systems diagrammatically. Examples of machines of this type will be given when dealing with actual applications, but it may be mentioned here that the method suffers from the drawback that highly skilled operators who possess a certain "feel of touch" are required for these machines. We may also note in passing that it was of course this type of mechanism in its simplest form from which the idea of the cam originated.

Two interesting applications used in the manufacture of turbine blades are shown in Fig. 4. The upper diagram shows the basic rotary method of blade profiling. The rotary table on the left carries the master (in this case twice full size owing to the leverage) and rotating in an anti-clockwise direction. Geared to this and rotating in the same direction are two other rotary tables carrying the actual blades to be machined. A spring loaded or weighted bell crank lever of the shape shown and having its fulcrum at the intersection of the respective centre lines of the links carries both tracer rollers and cutters.

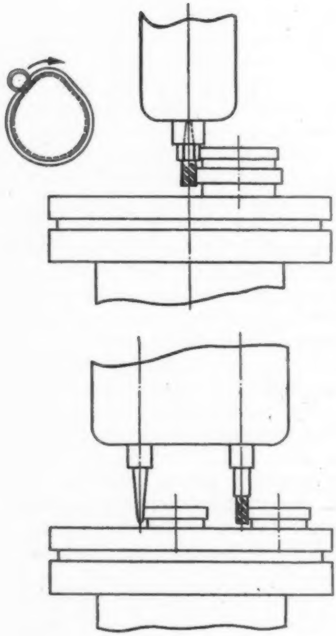
The lower diagram shows the basic linear method of blade profiling. It will be noted that the fulcrum of the arm carrying



Left—FIG. 1

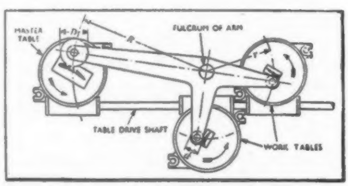


Above—FIG. 2

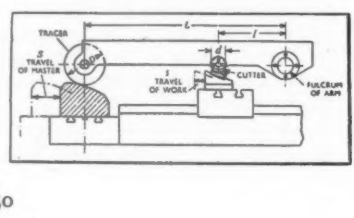


Left—FIG. 3

Below—FIG. 4



Basic Rotary Method of Blade Profiling



the tracer roller and the cutter in this case is at the end, but still on the same centre line. It is necessary in this particular method to maintain the relationship :—

$$\frac{\text{Linear Travel of Master}}{\text{Linear Travel of Work}} = \frac{\text{Dia. of Tracer Roller}}{\text{Dia. of Cutter}} = \frac{L}{1}$$

a matter which is not very easy to arrange in practice.

HYDRAULIC AND PNEUMATIC TYPES

(i) We now come to the second main group of following devices, viz., those relying on hydraulic or pneumatic circuits for their operation. These controls represent definite advantages over the mechanical types, in that they are superior as far as accuracy of reproduction is concerned. They are also faster and simpler to operate. Moreover, owing to the fact that a much smaller pressure is exerted on the master, there is no need for the latter to be made out of hardened steel. The actual pressure exerted by the tracer varies according to the size of the job and the actual application, but in many cases it is not more than about 3 to 4 ozs., and because of this the model can often be made out of wood or from a plaster cast which may be taken wherever applicable.

The principle of the hydraulic tracer valve on which the method depends can be seen from Figs. 5 and 6. Fig. 5 shows the system

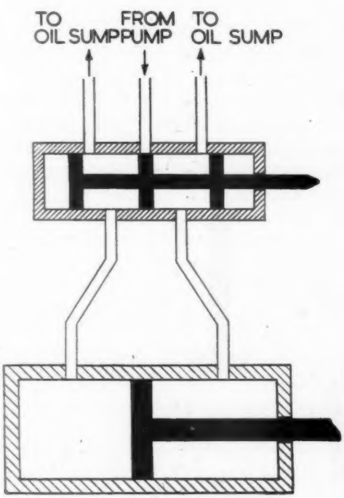


FIG. 5

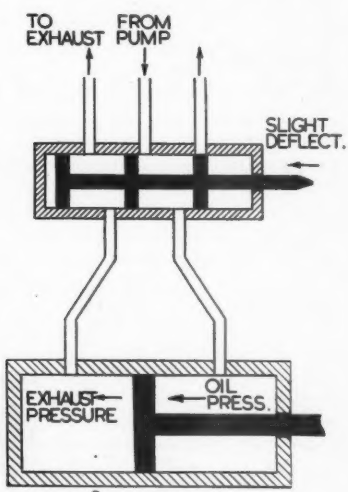


FIG. 6

in the equilibrium position with the inlet port, delivering oil from the pump, closed. When the tracer valve is displaced in either direction, the oil supplied from a rotary pump at between 120 and 300 lbs. per square inch, depending on the application, is passed to the corresponding side of the main ram cylinder shown in the lower portion of Fig. 6. Any back pressure which may have built up on the opposing side of the piston, owing to the oil present, is exhausted at the same time into the sump through the left chamber of the "bobbin" valve. A deflection of the tracer in the opposite direction will of course cause the main piston to be displaced in the opposite direction to that shown in the diagram. The tracer valve is always spring urged towards the master, so that as the machine feeds in this direction the tendency is for the valve to close, thus stopping any further movement.

The principle of this type of control is extremely simple in theory, but presents various difficulties when actually put into practice. It is, for instance, important that all oil pipes should be as short as possible to prevent any variations in accuracy which may be caused by the very slight compressibility of the hydraulic oil. Constant research is also being done to find methods of increasing the speed of reproduction, i.e., to decrease the time lag between the tracer valve opening and the main cylinder beginning to move. The movement of the tracer valve does not however correspond exactly to the movement of the ram cylinder, as the former acts as a pilot valve only.

A NEW TYPE OF VALVE

Lately a new type of "potentiometer valve" has been perfected by Metropolitan Vickers Limited. The principle of this will be seen in Fig. 7. In the position shown the openings (a) and (b) are equal in area and consequently the continuous flow of oil through the valve and back to the sump through pipe (c) causes half the supply pressure P to

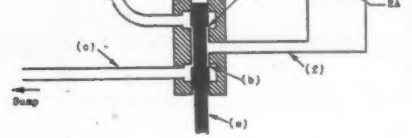


FIG. 7

drop across opening (a) and half across opening (b). The piston (d) is so arranged that if the effective area on the top side is A, the area on the bottom side is 2A. We therefore have the following relationships :—

$$\text{pressure on top of cylinder} = P \times A = PA$$

$$\text{pressure on bottom of cylinder} = \frac{P}{2} \times 2A = PA$$

i.e., the forces on both sides are equal and the piston will be at rest. If pilot valve (e) is displaced upwards, opening (a) is increased and opening (b) decreased by equal amounts. This results in a pressure increase in the lower portion of the chamber with a consequent upward movement of the piston, and it will be noted that this movement will again correspond to the movement of the tracer. Conversely, of course, a downward movement would result in a downward movement of the piston by increasing the pressure in the upper chamber and reducing that in pipe line (f).

It will be noted that in the latter type of tracer valve there is a continuous flow of oil being maintained, whereas in the former the oil flow is intermittent and only takes place when the stylus is being displaced in one direction or the other. It is claimed that this " live " hydraulic system has far greater sensitivity than systems in which the equilibrium position is obtained by closing a valve and shutting off the oil flow. Such valves always have a certain amount of overlap which, no matter how small, causes a lag in the response of the piston to motion of the tracer, with the result that there are " dead points." The disadvantage of the system is that, for equal power, a larger diameter cylinder will have to be employed.

USE OF SPECIAL DEVICES

It will be realised that a larger number of applications of this type of control are feasible in the field of machine tool design. Practically any movement on a machine may be controlled in this manner, but in order to achieve the desired result various special devices sometimes have to be employed.

Fig. 8 shows diagrammatically the operation of the Cincinnati " Hydrotel " 360° Control. Considering the upper diagram first, it will be seen that here we have two main ram cylinders with two separate feed control valves for operating the table traverse, and the transverse slides of a vertical milling machine for contour milling of shapes like that of the template shown. The respective movements of the feed control valve are in this case operated by a cam, and not directly from a master or template as before. It will also be apparent that whereas in our previous example the movement

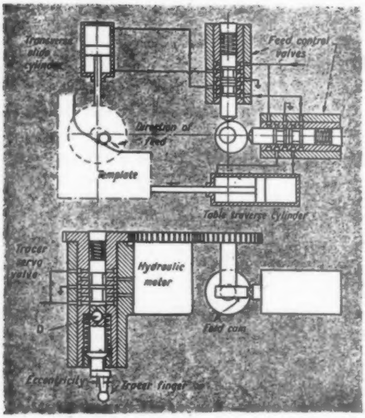


FIG. 8

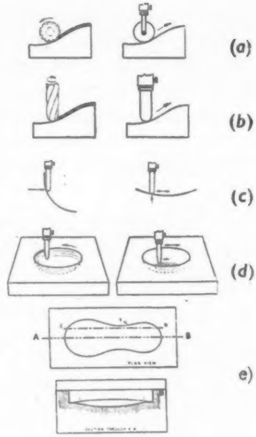


FIG. 9

of the cylinders was controlled by a direct up-and-down movement of the tracer valve, tangential contact pressure is necessary in this case.

The lower diagram will make it clear how this is being achieved. The tracer finger. which in this case has a slight eccentricity, is resting in a spherical seating and is spring loaded. Any tangential deflection of the tracer tends to rock the stem in its seating, thus forcing the ball resting in a conically shaped cavity at the top, in an upward direction. Tangential deflection of the stylus is thus converted to axial deflection of the bobbin valve which operates in a similar manner to that previously described, but in this case drives a hydraulic motor. This motor is geared to the inner sleeve carrying the whole tracer assembly, and the cam operating the feed control valve described above. It will thus be seen that the direction of the feed of the tracer finger must always be tangential to the profile, whatever its shape, because any tendency to do otherwise would automatically be corrected by the hydraulic motor revolving the inner sleeve in the opposite direction, thus bringing the finger back to its original position.

Fig. 9 is an attempt to show diagrammatically what type of tracer control should be employed in machining various contours ; (a) shows a horizontal milling cutter with a correspondingly shaped follower. This type of arrangement is generally employed in the " rise and fall table " machines mentioned when we were discussing mechanical followers.

(b) is a typical set-up used in die sinking and employing end milling cutters. This is a more usual form taken by tracer controlled milling operations, and the actual generating movement may be either of the quill control or the knee control type. The latter is generally preferable where a heavy rate of metal removal is involved but the quill control is usually cheaper and simpler to install.

LATERAL AND ROTARY SCANNING

Diagrams (c) and (d) show the relative advantages of lateral as against rotary scanning. Where the cavity to be copied is relatively shallow, lateral scanning is almost invariably used. This involves the taking of a series of consecutive parallel cuts, in each of which the up-and-down movement of the cutter is automatically controlled by the tracer mechanism. Theoretically speaking, the closer these cuts are to each other the smoother will be the finished profile, and an infinite number of cuts would result in a surface in all respects absolutely identical with that of the master. Practical limitations, however, are imposed by the fact that the last finishing cuts will often take as long as those used for the roughing and semi-finishing operation, and it is therefore usual only to semi-finish on such a machine, leaving the finishing and final polishing operations to be performed on the bench.

The left-hand portion of (c) shows what happens in the case of cavities with steep sides. Here lateral scanning would obviously be inaccurate due to the rubbing effect on the side of the stylus, and it is found that " spiral " scanning in which the cutter and stylus are lowered into the cavity with a rotary motion, is preferable. It is this type of control in which the 360° Edge Finder already described is normally used.

(e) shows a case where a combination of both edge control and depth control has to be employed. The normal procedure in tackling a mould of this description is to rough out by means of lateral scanning using depth control, and then tidy up the edges using the 360° control with rotary scanning.

(ii) An interesting development of the fundamental hydraulic circuit already described is that employed in the Monarch " Air-gauge " Tracer shown in Fig. 10. Here we have two entirely separate circuits, namely a power circuit using oil, and a servo-control circuit using air as a medium. Air enters the line at constant pressure as indicated by the first gauge. A specially designed air pilot valve maintains the air loading pressure in the supply line constant when the lever is in the neutral position. With a change in the contour of the template the pressure on the air pilot valve is either increased or decreased. If it is decreased, the valve bleeds some of the air from the system. Conversely, when the pressure on the valve is increased the air loading pressure, as shown by the

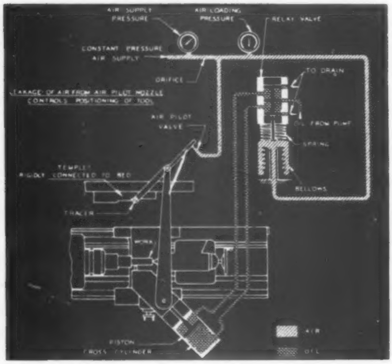


FIG. 10

second gauge, builds up accordingly. Any changes of pressure in the supply line are registered by spring-loaded air bellows which rise and fall in accordance with these changes and this movement is transmitted to the hydraulic control valve which regulates the flow of hydraulic oil to the main cylinder, as previously shown.

It is claimed that this arrangement is more sensitive to small changes in contour of the template and that the possible limits of accuracy to which the component can be machined are closer than in the case of the normal or direct hydraulic type of control. Against this it may be said that the arrangement is much more delicate, and the possibilities of breakdowns are consequently greatly increased. We shall consider an actual machine using this arrangement later.

ELECTRICAL TYPES

The electrical types of tracers can be divided into two broad groups, viz., the electro-magnetic types, and the newer devices based on electronic principles.

(1) One of the earliest devices of the electro-magnetic type is that used in the well-known Keller machines. In this we have three leadscrews operating the horizontal, vertical, and transverse slides and providing left-right, up-down, and in-out motions respectively. Mounted at the end of each leadscrew is a gear box with an individually variable speed drive motor. Each motor drives a pair of clutch magnets which rotate continuously in opposite directions. Energising one of these two magnets attracts its associate armature, which turns the leadscrew in one direction ; energising the other turns it in the opposite direction, thereby moving the particular

slide in one direction or the other. At any particular moment the action of the tracer selects the proper clutch magnets to give the motion as called for by the tracer following the model.

(ii) The schematic diagram of Fig. 11 shows the low equipment functions of a type of electronic control recently developed by Metropolitan Vickers Electrical Co. Limited, for use on lathes.

The arrangement consists of a tracer carrying a circular stylus which is capable of movement against built-up springs to the extent of a few thousandths of an inch in any direction in the horizontal plane. The function of the tracer itself is to resolve any deflection of the stylus into two voltages directly proportional to the components of the deflections in relation to the two feed directions at right angles. Mounted on the saddle of the lathe, in a position convenient to the operator, is a manual control unit. This embodies a directional bias control consisting of two continuously rotatable potentiometers on a common shaft. These are arranged to give two voltage outputs which, in series with, and in opposition to the corresponding two voltages from the tracer unit, are fed to two amplifiers. The push-pull D.C. outputs from these amplifiers energise the split fields of the longitudinal and cross feed motors.

Another interesting development making use of an electronic device in conjunction with an optical system, is that shown in Fig. 12. Here a continuously varying section, such as that of the turbine blade shown in the top right-hand corner, is split into a large number of planes A, B, C, D, etc., and a photographic copy is then made from a drawing of the various sections. The optical system consists of a strong light source with a chopper disc rotating at a high speed situated directly underneath as shown. The chopper consists of a disc with a number of small holes distributed over its

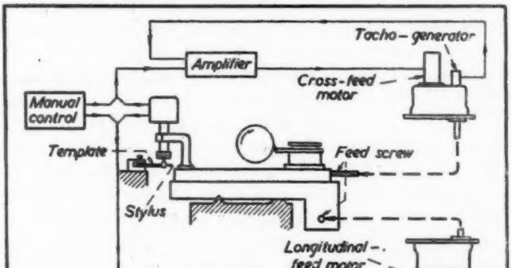


FIG. 11

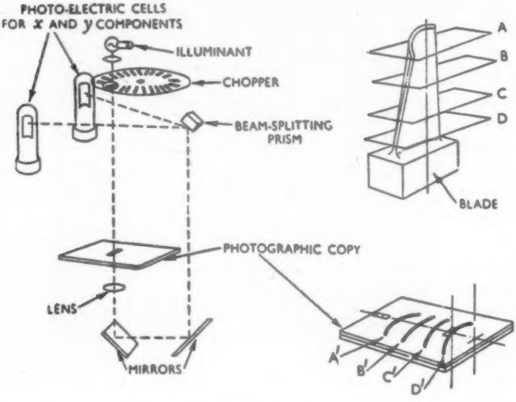


FIG. 12

surface, so that the photographic copy will in fact be subjected to a system of optical scanning which splits the picture up into a large number of dots of light varying in intensity. This system is similar in principle to that used in some of the early television cameras before it gave way to some of the more sensitive methods of scanning now used. The light which has been collected into a parallel beam by being passed through collimating lenses, is then deflected through mirrors as shown, and eventually passes through a prism which splits the beam into two rectangular x and y components. The photo-electric cells pick up these beams and after passing through suitable amplifiers, the current operates variable speed motors fitted to the respective leadscrews of the machine as before.

EXPERIMENTS WITH CONTINUOUS FILM The method just described is still in the development stage, and various experimenters are at work to solve some of the practical difficulties which present themselves. No concrete results have as yet been published, but it is believed that at least one firm is experimenting with a continuous film instead of the single photographic copy. The problem of the beam splitting device in this case is being solved by substituting a large chromium-plated screw whose rotation is synchronised with the chopper and the speed of the film. The screw has the same function as the prism in the example just described, i.e., it splits the beam into two components at right angles to each other by reflecting from the root and the crest of the screw at the same time.

Our discussion up to this point has been mainly concerned with the fundamental types of tracer controls available to the machine tool designer. We now have to turn to the main subject of this paper, viz., how these various devices can be adapted to actual manufacturing operations.

In order to facilitate the consideration of the many types of applications possible, we shall split up the subject into the various types of manufacturing operations and shall consider each one separately irrespective of the type of control used in each instance.

TURNING Turning is probably one of the oldest and at the same time still the most common of all metal working operations. It is therefore obvious that with the modern tendency towards large batch and flow production, attempts have been made to mechanise some of the manual work normally involved in repetition turning operations.

There are a number of turning operations differing fundamentally with regard to their application, and we shall now consider each one of these in turn.

(a) The turning of stepped shafts is probably one of the best known examples for the application of tracer control. Such shafts are used in a large number of different industries and gear shafts, electric motor shafts, axle shafts, stub axles, and similar shafts used in the motor car industry, are just a few of the many possible applications. It will, of course, be apparent that the relative savings on such operations are highest where large numbers of steps have to be machined. The idea of the copying lathe is now fairly well established, and the design of most of these machines is based on the hydraulic or electronic principles previously considered. Fig. 13 shows a standard lathe which has been converted for this type of work. The machine has been equipped with a sub-slide, to fit the normal cross slide, the rear end of which carries the tracer valve, whilst the front end carries the main pressure cylinder which, however, is only partly visible on the photograph. This cylinder controls the in-and-out feed of the tool, and it is particularly noteworthy that the pressure cylinder is situated at 45° to the movement of the cross slide. This arrangement enables a shoulder to be machined without disengaging the longitudinal traverse of the machine. This will be obvious from the relationship

$$\frac{\text{movement of main cylinder}}{\text{movement of saddle}} = \frac{\sqrt{2}}{1}$$

Thus, if the main cylinder retracts $\sqrt{2}$ times as fast as the saddle moves along, a square shoulder will be generated. The cylinder does not of course have to be arranged at 45° and we shall see later

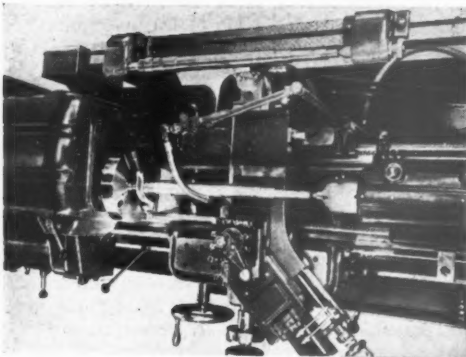


FIG. 13

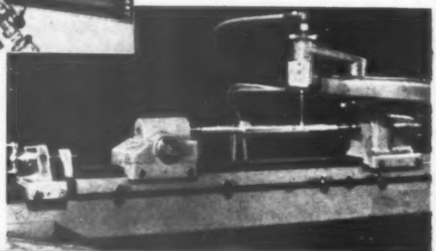


FIG. 14

FIG. 15

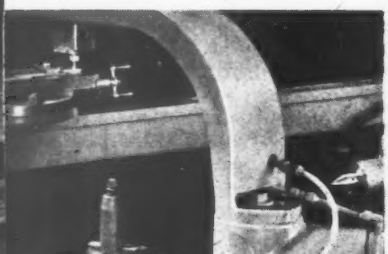


FIG. 16

that some of the manufacturers do in fact favour other angles. It will, however, be obvious that such results could not be obtained if the cylinder were to move in a direction parallel to that of the cross slide. Once the first diameter has been turned to agree with the corresponding diameter of the master shaft, the traverse can be engaged and all diameters will be reproduced automatically with the tool feeding in-and-out as the saddle moves along, without any further manual operation.

LIMITED APPLICATION The one serious limitation to this type of control is that only shafts can be dealt with which are stepped in one direction. In most cases this would make little difference, as the shaft would have to be reversed in any case to turn the other end where the carrier or chuck is secured. However, if it should become necessary to machine both sides of a shoulder in one setting, or if complicated forms have to be dealt with, such as those sometimes encountered in form rollers, the double — 45° control has to be used. This consists of two cylinders arranged at 45° and on opposite sides of the cross slide, forming a right angle between each other. A simple change-over valve is used for engaging either one or the other cylinder as applicable. The change-over is best accomplished whilst the machine is turning a parallel portion of the shaft.

Whatever arrangement of cylinders is being used, the general method of holding the model is similar in each case. Copying may be carried out either from an actual shaft which has previously been turned by conventional methods, or from a template corresponding to the form to which the shaft has to be machined. Fig. 14 shows the model holder for round masters provided on the Monarch Air Gage Tracer, whilst Fig. 15 shows the arrangement for flat templates on the same machine.

The question of whether shafts or templates should be used as masters is largely one of expediency. Templates have the advantage of taking up less storage space but on the other hand they are generally more difficult to produce and therefore more costly. Fig. 16 shows the main ram with the overbracket for the tracer support on the Air Gage Tracer. This arrangement is somewhat clumsy, but has the advantage of leaving the tracer comparatively unaffected by vibration and chatter due to the actual cutting conditions. It also enables a relatively quick change-over to internal form turning operations where this should be required.

Whatever method of support is being used for the master, some arrangement has to be made for adjusting the model in a direction parallel to that of the lathe bed. This is necessary for setting purposes before machining commences and once set, must not be disturbed as long as the particular type of component remains in

production. For this reason some method of locking these controls after they have been set is usually provided. There are several "special" machines which have been developed for this class of work, and, whilst similar in principle, these often differ fundamentally in general design and appearance.

An interesting example of such a machine is the lathe built in Switzerland by Messrs. George Fischer. Fig. 17 shows the principle on which the machine operates. The oil sump, tracer, etc., in this case are all built into the carriage so that there are no external projections of piping and other obstructions. A gear pump (17) delivers oil into the ram chamber (19) from where it flows through the port at the top and down the central gateway. The tracer finger (22) is hinged at the centre and carries at its opposite end a valve (21). The compression spring (23) normally keeps the valve (21) open so that the oil in the chamber flows back into the sump, completing the circle. If, however, the tracer is brought into contact with the master, this tends to close the valve either wholly or partly, depending on the amount of deflection, thus restricting the oil flow from the ram. As the pump delivers against a fixed head, the amount of oil in the chamber increases, thus forcing the tool slide to move outward against the shaft being machined.

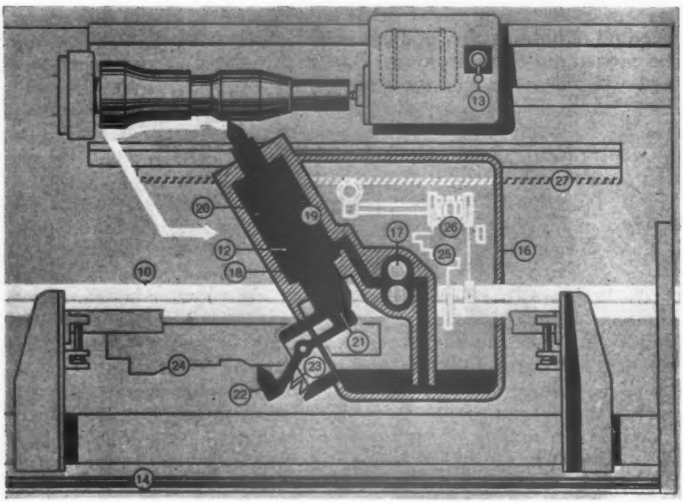


FIG. 17

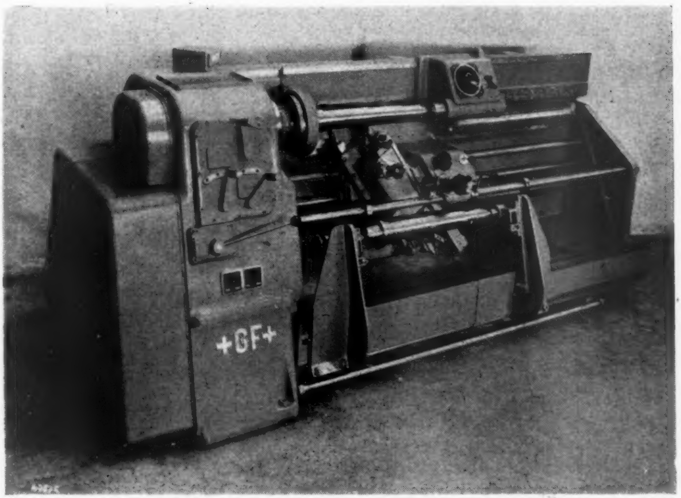


FIG. 18

A general view of the machine is shown in Fig. 18 and it will be noted that the slide is arranged vertically in this case, and forms a 60° angle with the axis of the shaft. It will be remembered that in the case of the other machines discussed the angle formed was 45°. The specially designed tool post, carrying a very heavy carbide tool, supports the tool to the very tip without any overhang and thus allows exceptionally heavy cuts to be taken. The machine is very clean in appearance and the vertical slide arrangement allows swarf to fall clear without blocking up any essential parts. Air clamping of the component decreases the operation time still further, but it must be remembered that these machines can only be used for shaft-copying whereas the equipment discussed earlier can if necessary be used for ordinary turning work. The procedure necessary in these cases is simply to switch off the main control valve, thus locking the sub-slide solid in relation to the cross-slide itself. Fig. 19 shows a rather spectacular example of a component being copied automatically on the G.F. Lathe, without any measuring or " miking " being necessary on the part of the operator. Some idea of the speed of hydraulic copying on one of these machines will be gained by an examination of the operation times given in Fig. 20, which are typical.

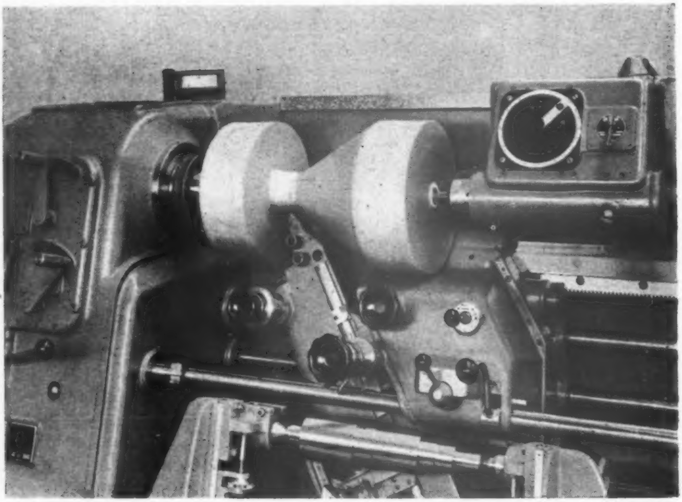


FIG. 19

SPECIAL CONTOURS

(b) Whilst the two arrangements just described allow for shoulders, tapers, etc., to be turned with ease, the turning of special contours provides greater difficulties. Problems of this kind are, however, often encountered in certain trades and an example is the manufacture of glass dish moulds. In addition to the shape of the mould itself, the characteristic ribbing on some of these moulds has been taken care of during the actual turning operation. Owing to the slow speed at which shapes of this kind normally have to be turned, however, it is only practicable in most instances to rough out the shape on the machine itself, leaving the final finishing to be done by hand. Fig. 21 shows two examples of glass mould manufacture being carried out on the H.E.B. Copying Lathe specially designed for this work. It will be noted that the upper of the two illustrations shows a special arrangement providing for the female cavity to be copied from a male master.

(c) There are some special applications of copy-turning work which may be mentioned here in passing. An example, again from the glass industry, is the turning of moulds for glass bottles not of round section, such as medicine bottles. Formerly the procedure in making such moulds was to split the mould and die

sink each half separately, but it will be obvious that considerable savings can be effected if the mould can be turned in one piece without splitting.

One of the latest developments for turning contours not of round section is that designed by Alvie Kellie and incorporated in the machine known as the Monarch Shapemaster. Essentially the device consists of four main elements. First, the master record which controls the shape of the cut. Secondly, the special change gears in the machine which give control, over the rate of repetition of pattern on any given circumference. Thirdly, the

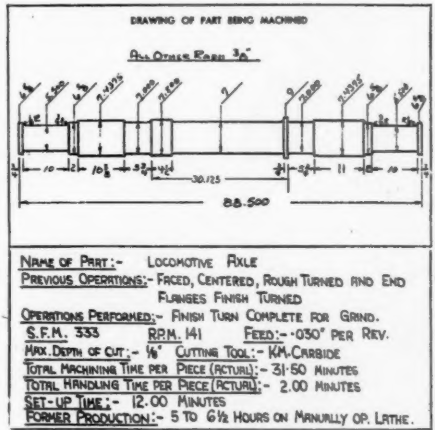


FIG. 20

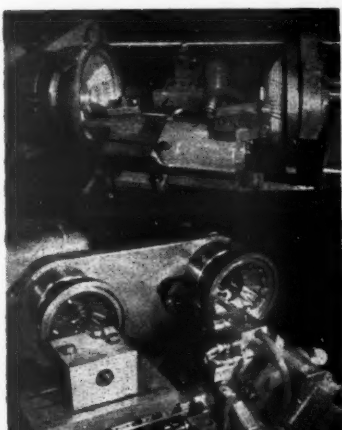
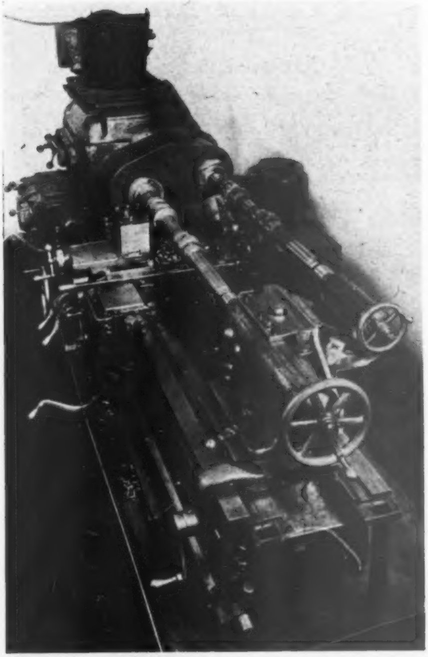


FIG. 21

FIG. 22



stroke adjusting mechanism which pantographs the shape of the master record through linkage to the movable tool carrier supporting the tool during its shaper-like stroke. Fourthly, the linkage mechanism which controls the relationship between the longitudinal feed and the longitudinal movement of the master record.

Briefly, the sequence of operations in manufacturing a mould is as follows :—

A hand-made template is mounted in the work-holding chuck

FIG. 23

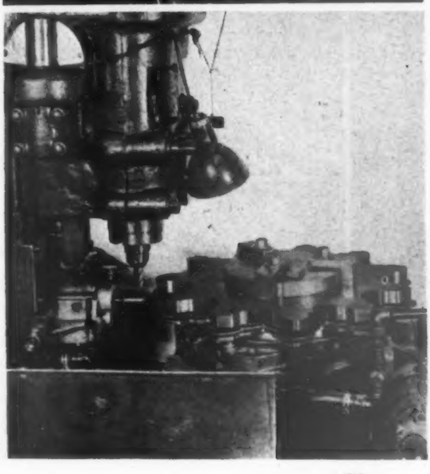


FIG. 24

and slowly rotated. A sharp-pointed tracer is fixed to the cross slide in contact with this template, thus transmitting the design on the pattern through the pantograph mechanism to a small motor-driven milling cutter at the rear of the carriage. This accurately forms

the pattern design on to the rotating master record, as will be seen from Fig. 22. Having completed the master record, a roller replaces the milling work and the cutter piece is placed between the lathe centres or chucked in the usual way. Then by means of a linkage mechanism in combination with the pantograph mounting and the gearing built into the machine, the movement of the cutting tool is controlled. By these means almost any desired shape can be given to the work piece, either inside or outside and across the face. The machine is largely used for engraving work, as well as ordinary copying, and it should be noted particularly that in this particular case the master record does not correspond to the shape of the final work, being many times larger than the latter.

Another interesting special application shown in Fig. 23 is the turning of a cam shaft on a standard lathe fitted with a pressure ram moving in line with the cross slide. It will be noted that in this instance, as in the previous one, it will be necessary to rotate the master as well as the work piece, and to overcome this difficulty a special gear box is fitted to the headstock as shown. The ratio :—

$$\frac{\text{rotation of master}}{\text{rotation of work}} = 1$$

and special precautions have to be taken in applications of this kind to take care of the variations in rake and clearance as the work rotates. To ensure that the heel of the cutting tool at no time rubs against the workpiece, a large front clearance has to be provided and this results in a comparatively weak tool point, thus rendering it incapable of taking heavy cuts. This, together with the necessity of rotating the workpiece comparatively slowly because of the time lag necessary for the hydraulic equipment to function after the tracer valve has opened or closed, makes this particular application of experimental interest only. It would not generally be considered a proposition in the machine shop except where other methods are inapplicable for some reason or other.

MILLING It is in the field of milling that tracer controls are probably most widely known. Many different devices have been employed in this field, making possible operations ranging from profile milling of cams to the more complicated die sinking operations. Due to the various methods of scanning employed, it is generally possible to copy-mill even complicated forms by the two dimensional control, and recourse to the three dimensional type has to be taken but rarely.

(a) *Profile Milling*. Profile milling or form milling is generally employed in the case of cams and similarly shaped components. The method used is usually of the template and roller type, although the mechanism used is sometimes hydraulically assisted as in the case

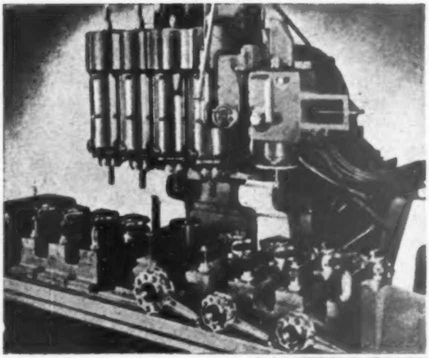
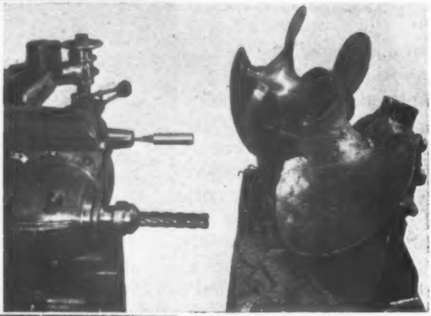


FIG. 25

FIG. 26



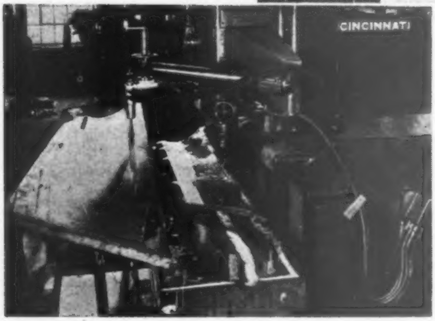


FIG. 27

of the Cincinnati "Hydromatics." Here we have a simple mechanical following device using a rise and fall spindle. The hardened steel cam controls the rate at which the spindle rises for a given advance of the table. The contact pressure between the cam and the roller is equal to the weight of the spindle assembly. Only comparatively gradual changes in contour can usually be dealt with in this manner.

As previously explained, the master may be positioned either side by side or above or below the workpiece. The side by side method has been used in the design of various special purpose profile millers of which the Gorton Machine is a typical example. This machine is equipped with a special table running on balls and rollers, and the work of the operator is facilitated by the single lever "Joystick" control which allows two dimensional contours to be followed very easily.

The drawback of this type of machine is again that contact between master and follower is maintained purely by hand pressure, i.e., by the "feel" of the machine operator who will necessarily have to be fairly skilled.

The difficulty is overcome by the substitution of the hydraulic tracer for the mechanical type. An example of such a set up will be seen in Fig. 24, which shows how a large sprocket wheel may be machined on a vertical miller. The template for this particular component is mounted on a geared circular table, with the tracer valve mounted horizontally to engage with the template. As the table rotates the template engages with the tracer, which in turn controls the cross feeding and retracting of the saddle to give the profile required.

This set-up suffers from the disadvantage, apart from being somewhat expensive, in that insufficient swarf clearance is provided. As the controlling part of the mechanism i.e, the tracer valve, is situated below the component, inaccuracies are likely to occur due to metal chips lodging themselves in between the tracer and the template, unless a really copious supply of coolant is being used.

Normally it can be claimed that the side by side method is preferable and it is this method which is used in the 4-spindle Cincinnati 360° Profiler (Fig. 25), of which the principles were discussed in earlier sections. It will be seen from the illustration that in this instance four radial engine connecting rods are being machined simultaneously from a single master. A similar machine with two spindles is used to machine the profiles of a small propellor blade. Here, however, the quill control is used and not the edge finder as in the previous machine. In work of this nature rotary scanning is usual. Here the model rotates slowly about parallel axes whilst cutter and tracer move in a single plane only, thus

generating the desired form. This is also the method used in the operation shown in Fig. 26. Here, however, tracer and cutter are moving in a horizontal plane.

In order to increase the ratio of model size to work above 1, pantographs are occasionally used as in the example shown in Fig. 27. Such an arrangement tends to increase the accuracy of reproduction, as any machining errors in the model are reduced in the ratio to which the links of the pantograph are set. It may be noted in passing that engraving machines which have to produce work of extreme accuracy are generally constructed on this principle. Due to the comparatively light pressure required in this class of work however, mechanical means of reproduction normally are used for such work.

(b) *Die Sinking*. Here again pantograph machines are extensively used, particularly for fine work because of the convenience of being able to employ a larger master. This results in increased accuracy of the finished work, but as previously mentioned, the method is somewhat slow and laborious and a skilled operator is required to look after the machine. In order to facilitate more rapid operation and dispense with the need for a skilled operator, automatic scanning devices such as the one shown in Fig. 28 have been fitted in some instances. Here the tracer finger is carried on auxiliary cross slides and the direction of feed is reversed automatically at the end of the stroke through a system of limit switches. A small increment of feed is put on at each reversal and the equipment is fitted with overriding manual control. A noteworthy feature in this particular design is the rotation which is

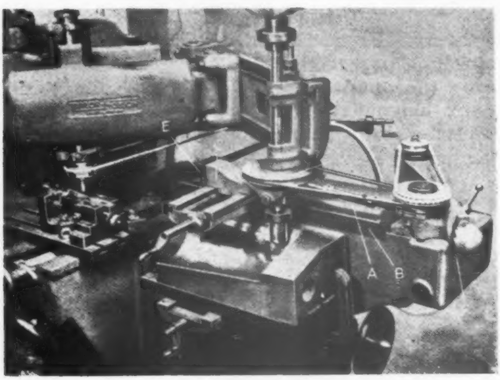


FIG. 28

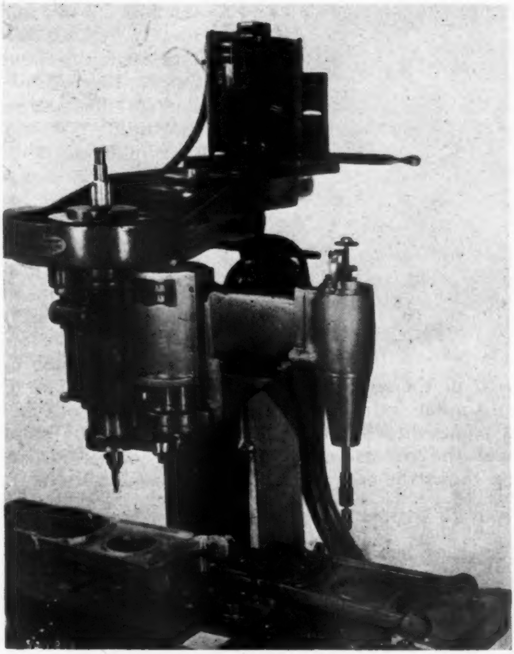


FIG. 29

imparted to the stylus through Pulley D. The purpose of this is to distribute wear over the surface of the stylus and reduce friction when operating on an upward gradient.

Another type of die sinking control using the hydraulic principle is shown in Fig. 29. In this particular illustration it takes the form of a self-contained unit which is fitted to an ordinary horizontal milling machine. The control may be either of the quill or knee type.

In the knee control the ram cylinder is fitted underneath the knee assembly of the machine, resulting in the table rising and falling with a change of contour of the master. In the quill control the table stays fixed in the vertical plane and the change in contour is effected by an up and down movement of the quill itself. The knee type of control is generally preferable where the work to be

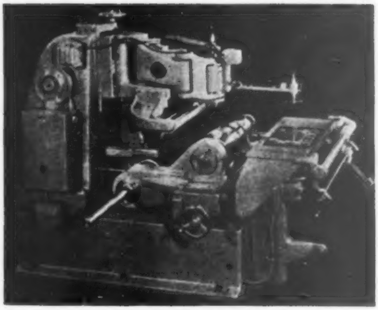


FIG. 30

machined is of a fairly heavy nature. Scanning on this type of set-up may be of the axial or rotary kind, depending on the nature of the machining operation.

A machine of somewhat specialised nature and using hydraulic quill control is shown in Fig. 30. It has been included here only for general interest to show how the equipment may be adapted for special purposes. The machine is a Gorton Vertical Roll Engraving Machine, and is used in the manufacture of rollers intended for the wall-paper and similar industries. The special feature of this machine is that it copies directly on to a roller from a flat template, the indexing of the roller being achieved by direct gearing. The illustration shows the engraving of a roller used in the manufacture of paper doylies.

PLANING AND SHAPING

Form planing is a comparatively rare and somewhat unusual operation which is nevertheless capable of a certain amount of development. An application where tracer mechanisms have been applied and have shown considerable saving is in the planing of rotors for diesel engine scavenging pumps of both the two and three lobed types. Fig. 31 shows such a rotor held in a suitable trunnion fixture to facilitate rapid and accurate indexing. The rise and fall of the tool head is controlled by the usual ram cylinder, whose movement is governed by the tracer following a correspondingly shaped template. If the rotor should happen to be of the spiral type, this method can still be applied by arranging a suitable gear train for rotating the component in the fixture for a given advance of the planer table.

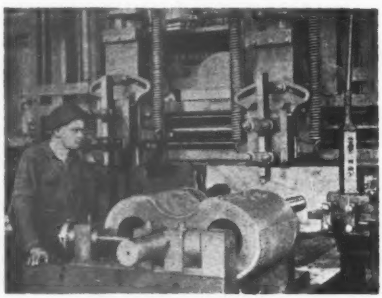


FIG. 31

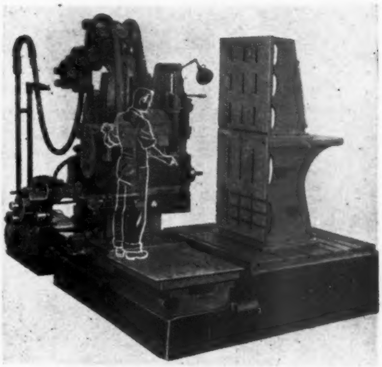


FIG. 32

A relatively new development is the introduction of a shaping machine equipped with hydraulic copying attachment and manufactured by the Cincinnati Shaper Company of America. The machine is designed to produce a profile on a circular work piece and in operation the feed is applied to the rotary table. The vertical movement is obtained by means of the usual hydraulic cylinder fitted to the leadscrew normally used for controlling this motion. A stylus in contact with the template controls the flow of oil to the cylinder as previously described.

BORING (a) *Horizontal Boring.* Whilst there are some standard horizontal borers which have been converted to copy milling or boring operations, most operations of this type are now carried out on machines specially designed for this purpose. The well-known Keller Machines (Fig. 32) may be included in this class. As previously explained these machines are operated through a system of magnetic clutches.

FIG. 33

A typical application carried out on a standard horizontal borer is the copy-milling of a motor-car body die shown in Fig. 33. The machine has been specially fitted with hydraulic tracer equipment to control the in-and-out movement of the main spindle, and

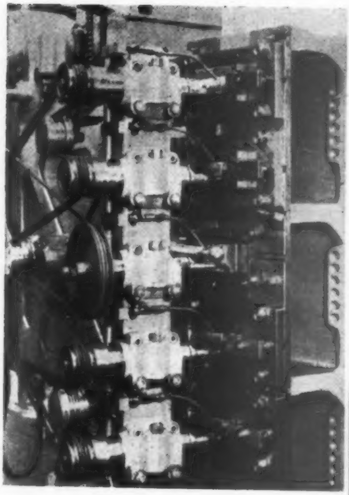


FIG. 34

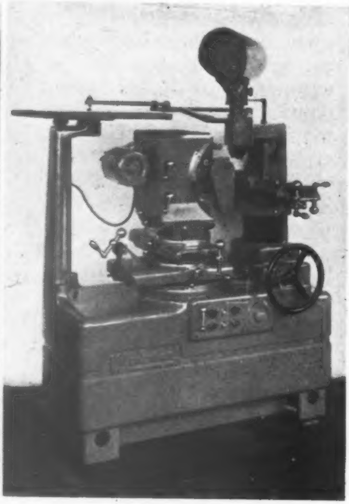


FIG. 35

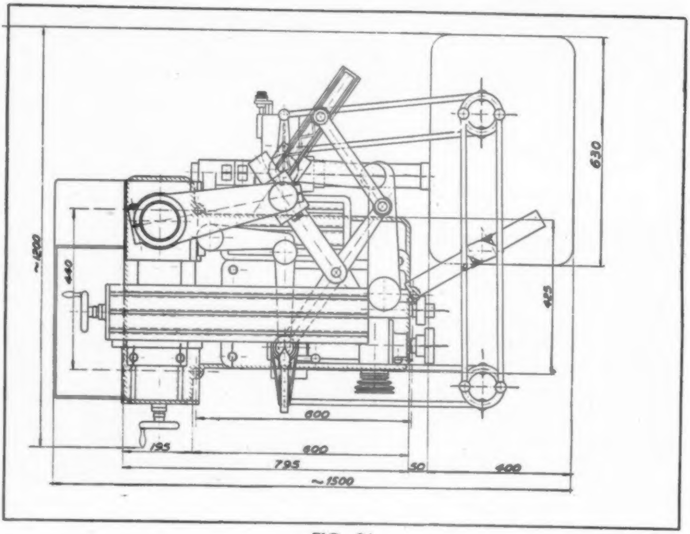


FIG. 36

shapes like the one shown are obtained by lateral scanning. As usual, the wooden model is mounted at the top and the die itself, in the lower position, clearly shows the rough machining marks obtained through scanning in both vertical and horizontal planes.

(b) *Vertical Boring.* One of the few applications of tracer controls to vertical boring mills is found in a Bullard machine of standard design which has been fitted with a 60° tracer slide for the turning of tyre flanges on railway wheels, locomotive pistons and similar applications. The angular slide arrangement has the same object as in the case of the lathe, i.e. it enables the tool to retract whilst the saddle is feeding across from right to left, thus generating a square shoulder.

GRINDING (a) *Production Grinding.* As an extension to the remarks made in a previous section, and in order to quote one of the few examples of tracer controlled production grinding operations, we may just briefly consider the machine illustrated in Fig. 34. Here we have a Pratt & Whitney Multi-Spindle Machine designed for form grinding four turbine blades simultaneously from a single master. The machine employs carbide burrs and is purely designed for finish grinding after the blades have been roughed out and semi-finished on a Keller machine of similar design, but using end mills instead of burrs.

(b) *Toolroom Application.* Toolroom grinding applications are more widespread and have been recently the subject of a great deal of research. Apart from finish grinding of form tools, punches, templates etc., a very interesting and relatively new technique consists of splitting press tool dies into two or more sections and form grinding each portion of the die separately, if necessary by reversing the original template. Fundamentally most machines designed for form grinding of this nature fall into one of three different classes :—

(1) where the movement of the microscope or viewing screen carrying appropriate hair lines is controlled by the tracer.
(2) where the movement of the grinding wheel is controlled by the tracer.
(3) where the wheel is diamond ground or crushed to the desired form, the diamond being guided by a tracer through suitable linkages.

Owing to the large number of special machines developed for this class of work, and the complexity involved, we shall only consider one machine of each type, the examples chosen being more or less typical.

(1) We have already considered the principle of this class of machine in a previous section. Briefly the microscope or viewing

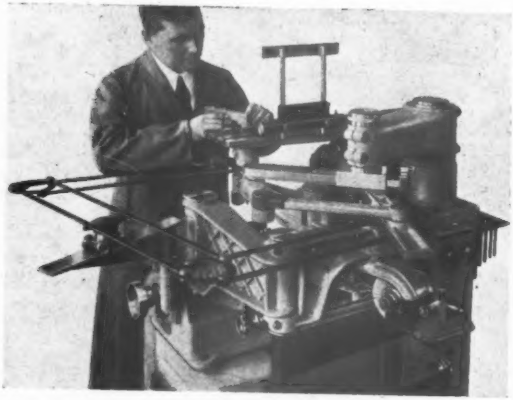


FIG. 37

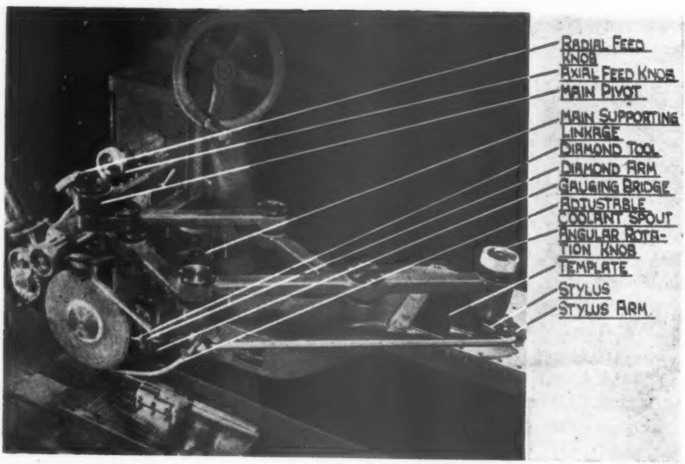

RADIAL FEED KNOB
AXIAL FEED KNOB
MAIN PIVOT
MAIN SUPPORTING LINKAGE
DIAMOND TOOL
DIAMOND ARM
GAUGING BRIDGE
ADJUSTABLE COOLANT SPOUT
ANGULAR ROTATION KNOB
TEMPLATE
STYLUS
STYLUS ARM.

FIG. 38

screen, both of which are interchangeable, is attached to a 50:1 pantograph. The tracer point is then moved along a large scale drawing pinned to the board provided for this purpose, and this will move the viewing screen or microscope at the same ratio. Both viewing screen and microscope carry hair lines with a small circle at the centre. The movement of the grinding wheel is then controlled by a series of cross, transverse, and vertical slides and rotary guides which enable the grinding wheel edge to be brought into tangential relationship with the circle at the centre of the cross lines. The process is repeated until the desired contour has been completely ground. Fig. 35 shows the optical profile grinder built by Messrs. Wickman Limited of Coventry which makes use of this principle.

(2) Fig. 36 shows the principle of the Studer Machine, which combines a pantograph with up to 50:1 reduction from the template size, with a duplex parallelogram linkage for angular wheel orientation in relation to the tracer. The machine, a general view of which is shown in Fig. 37, is capable of extremely accurate work and is largely used in the manufacture of tools and dies in the watch and clock making industry.

(3) Our final illustration, Fig. 38, shows an American design of pantograph linkage for use on surface grinders, combining for the first time diamond dressing of the wheel with crush grinding. The normal procedure is to true the wheel with the diamond whose movement is controlled by the tracer through the pantograph. The wheel can then be used for grinding the crusher roller, which is situated behind the wheel and which will then maintain the wheel profile almost indefinitely until a new contour is required.

FUTURE POSSIBILITIES

Our discussion on tracer controls has been mainly divided into the two broad groups of principles and applications. Before concluding our discussion of this type of machine tool, we may ask ourselves, what are the future possibilities of these controls?

It should be obvious from an examination of some of the controls described that the field is still relatively unexplored, and many more and improved suggestions will present themselves to the specialist. Development work is particularly being carried out with regard to the electronic types of control, but work is also being carried out on automatic and semi-automatic scanning devices using combined optical and electronic servo systems. Mention has already been made of such a device using film for recording of continuously varying sections, such as those encountered in the manufacture of turbine blades.

Some experiments have recently been carried out in Germany with a view to controlling the movement of machine members by

means of an automatic tape record. The method may be likened to that of the old-fashioned musical box. Whereas in the latter a roller with raised cams was used for operating spring levers to produce notes of different pitch, the idea behind this latest development is exactly the reverse process. Each of the three leadscrews of, for example, a milling machine, is fitted with a special contact ring in addition to the normal hand wheel. The various contacts are connected to a frequency generator which records the speed and frequency of each movement on a magnetic tape. The machine can then be made fully automatic by " playing back " the " tune " recorded on the tape, using telephone type frequency relays for operating special motors fitted to the slide controlling the various movements.

Other firms are experimenting in America with punched hole master cards giving details of the operation required. These are then inserted in the machine which completes the operational cycle required through a series of relay systems without any further setting—an idea which would appear to be the dream of every Production Engineer.

ACKNOWLEDGEMENTS The writer's thanks are due to a large number of authors and firms who have done previous work in the field of tracer controls, and who have spared no effort in kindly assisting with regard to technical information. He would, however, record his special thanks to the following companies who have given considerable help in the preparation of this paper :—

Catmur Machine Tool Corporation Ltd.
Charles Churchill & Co. Limited.
Alfred Herbert & Co. Limited.
Sydney G. Jones Limited.
Rockwell Machine Tool Company, Ltd.
Taylor, Taylor and Hobson Limited.
Wickman Limited.

ANNUAL DINNER OF THE INSTITUTION

Tuesday, 2nd October, 1951.

FIVE hundred members and guests assembled at the Dorchester Hotel, London, W.1, on Tuesday, 2nd October, 1951, on the occasion of the Annual Dinner of the Institution. The President, Major-General K. C. APPLEYARD, C.B.E., T.D., D.L., J.P., occupied the chair, and the Guest of Honour was The Honourable W. R. HEROD, Co-ordinator of the North Atlantic Treaty Defence Production.

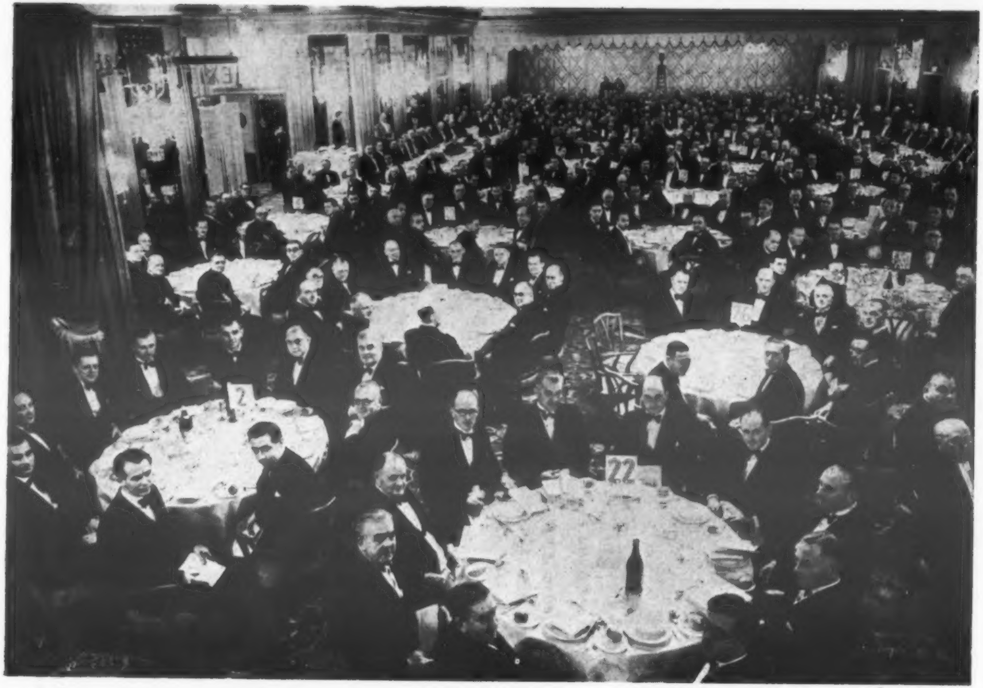
During the course of the evening, the President, on behalf of all members and guests attending the Dinner, despatched a loyal telegram to Their Majesties the King and Queen. The following reply was received :—

> ***"Please convey to the Council and members of the Institution of Production Engineers and their guests from the Empire and the United States dining together this evening, the sincere thanks of the King and Queen for their kind message of good wishes."***

THE ENGLISH SPEAKING PEOPLES

The Loyal Toasts having been duly honoured, the President, in proposing the toast "The English Speaking Peoples," said that one of the great ties of English speaking peoples was the feeling of belonging to one family. It seemed that the historic task of Britain, who was, after all, the mother of the English speaking peoples, had been to send her young men overseas and then after some time to "hive off" whole nations who had reached the age of maturity and determination to govern themselves. One of those nations "hived" itself off rather abruptly and completely some years ago, and unlike the others did not decide to remain in the family. In spite of that separation, however, that great nation, the United States, had twice within a lifetime stood beside the remainder of the family and had shown by her courage and determination that no power, however ambitious, would be allowed to destroy all that the English speaking peoples stood for. (*Applause*).

Dealing with the industry, the President said that Britain had almost a hundred years of pre-eminence and near monopoly in industry, and it suited her markets very well. The young countries,



ANNUAL DINNER OF THE INSTITUTION
Dorchester Hotel, London, 2nd October, 1951

on the other hand, had different conditions with which to contend, and their way of development was very different. There was a fight for existence, and there was still a fight for existence in many of them even under conditions of expanded population. There was the certainty that unless things could be produced at a reasonable price they would go under, for there was no government or anybody else to help them. That led to new ideas and new methods, and on top of it all, high rates of pay. Great distances forced upon those countries a choice of efficiency or failure. Now, in Britain, after years of low wage rates and so forth, the problem of high labour costs had to be faced, but that need not give rise to worry provided men would work. It was regrettable that wages were inflated, but industry should rather concern itself with better management, more unity within the various concerns, more power to each man's hand—and he referred to electrical and mechanical power—less waste of each man's time, and the replacement of manual labour by machinery wherever it was reasonably possible.

THE INSTITUTION'S OPPORTUNITY

There was a great deal to do, continued the President, especially within the scope of the Institution. In spite of all the frustrations of government control, however, much of which was necessary in war though irksome in peace, production had been rising year by year. " But if we were free to develop as we liked," he said, " if we had access to raw materials, we could multiply production enormously." There were thousands of firms in this country which had not yet been touched by modern production methods, and there were thousands more which had been touched but which were not able to spend the money on doing that which they knew should be done. Unhappily the time when they would be able to do so was postponed, the reason for the postponement being an overriding one which had to be accepted.

However, a great deal could still be done even in the present situation. Much could be done without capital expenditure to avoid wastage of labour, time and materials. No concern could afford inefficiency and waste, for upon the efficiency of the industries of all English speaking countries the future would depend. Industry alone could earn the money to defend and to improve the social and economic life of all the English speaking nations. No amount of political poppycock from whatever quarter it came could alter that fact.

Having paid a warm tribute to those who led the fighting services, and the Civil Service for the magnificent work which they did behind the scenes without being known to the population as a

whole, the President concluded by expressing best wishes to engineers of every kind in all the English speaking countries, particularly to the flourishing membership of the Institution. (*Applause*).

Response by The Hon. W. R. Herod

The Honourable W. R. HEROD (Co-ordinator of the North Atlantic Treaty Defence Production), in response, said that it had been his good fortune to know the President since the middle thirties when both he and the President were associated with the same group of companies. Apart, however, from the personal element it gave him great pleasure to respond to the toast, as all present were interested in production which was of great importance in the present scheme of things.

THE DOMINATING ISSUE

The dominating international issue continued to be the ominous division between the so-called Western countries on the one, hand and the Soviet with its associated or satellite nations on the other. The attitudes and actions of the Soviet and other Kremlin dominated governments had involved intolerance together with the disregard of the views and rights of others, and that situation had forced the West to increase its military strength, not for the purposes of aggression but for purposes of defence. A greater measure of Western military strength would appear to be necessary to the security of the West, and in order to promote peace through command of that degree of respect which would operate as a check or deterrent to those Kremlin inspired forces. Accordingly, twelve Western nations, building upon foundations of mutual respect and common civilisation but, above all, realising their common danger, some two years ago linked themselves together defensively in the North Atlantic Treaty Organisation, otherwise known as NATO. The NATO nations had been forced to embark upon a programme of rearmament and such rearmament efforts, it was hoped, could be internationally correlated among the NATO nations in such a fashion as both to strengthen them individually and, through mutual reaction, contribute to an even more greatly increased common strength.

ADVANTAGES OF NATO

The aggregate material potentialities were predominantly in favour of the NATO countries, and to quote a few figures Mr. Herod said that the population of the twelve NATO countries was approximately 340 million people, compared with probably not quite 300 million for the USSR and its European satellites. China, whose manpower was enormous, was omitted because its strength in other fields was doubtful. In national income the aggregate of the NATO nations was some three to four times that of the Kremlin dominated areas. NATO

countries had perhaps four to five times the amount of steel production per year. Roughly comparable ratios, i.e. four or five to one, would appear to apply in the case of electric power availability. In total energy used for productive purposes—taking all energy, electrical, mechanical, animate and inanimate—the aggregate in 1948 for the twelve countries had been estimated as over three times the corresponding aggregate for the Soviet Union and its present European satellites. In skilled labour force, and in the heritage of technology, the NATO countries greatly exceeded the entire Communistic group of nations.

Furthermore, whereas the Soviet with its European satellites on the one hand and China on the other had the great strategic advantage of central location and continuity of area, the NATO countries would appear to be more favoured, at least at present, with respect to access to the resources of other areas not so directly involved, for example, in Western Europe, in Africa, in South America, in Australasia and even in some portions of Asia. But in that appraisal, continued Mr. Herod, one must not overlook what appeared to be a tremendous increase in industrial production in the USSR. Statistics were, of course, always open to question, and particularly so in connection with the USSR where confirmatory visual evidence was lacking ; but if the figures given by the United Nations in the " Economic Survey of Europe in 1950 " were taken as representative, it would appear that the Soviet Union increased industrial production in 1950 as compared with 1949 by some 23 per cent, and reached a level some 73 per cent higher than in 1940.

It was interesting to note, in that United Nations publication, certain reported 1950 production figures or estimates derived from relating indices to previously available data for the USSR which appeared to be particularly significant. For example, 27.3 million tons of crude steel, reported as being produced in the USSR in 1950, i.e. 4 million more tons than in 1949, and almost 10 million more than in 1937; 260 million tons of coal and lignite, some 26 million tons increase over 1949, and over double the 1937 total of 128 million tons; 90 billion kilowatt hours of electric energy, an increase of 12 billion as compared with 1949 and 2½ times the figure for 1937; 37.8 million tons of crude petroleum, 4 million over 1949 and approximately one-third greater than in 1937; 10.2 million tons of cement, over 2 million tons more than in 1949, and almost double that of 1937.

INDUSTRIAL EXPANSION IN USSR

Further, as measured in terms of world totals, the Soviet Union in 1950, according to the same source, would appear to have been contributing between one-fifth and one-sixth of the world's total of industrial

production. That compared with some one-fifth to one-quarter of the world's total for the aggregate of the United Kingdom, Sweden, Norway, Denmark, Belgium, Luxembourg, France, Italy, Netherlands and Western Germany ; and could be compared with perhaps two-fifths to one-half of the world's total for the United States. Also, the relative growth in the few years from 1947 through 1950 of USSR industrial production on an index or percentage basis appeared, according to those figures, to have considerably exceeded the corresponding percentage growth during the same years of the aggregate of the Western European countries previously mentioned, as well as of the United States.

" Obviously," continued Mr. Herod, " we should not go too much on statistics, particularly for areas East of the Iron Curtain ; but the League of Nations before its demise, indicated the rather remarkable industrial expansion of the USSR, and I mention these recent United Nations figures to show that there has presumably been a considerable expansion in the industrial production of the USSR, and perhaps also in certain of its European satellites." Together they would appear from the United Nations figures to have represented, say, one-quarter of the world's total industrial output in 1950—an amount by no means exceeding in absolute terms that of the Western countries mentioned. But in relative or percentage terms, the increase in the four years 1947-1950 of the USSR and its satellites would appear to have attained a rapid rate of growth, comprising, according to the figures, some two-fifths to one-half of the world's growth in that four-year period.

If those figures were at all representative, it meant that the West must not sit by complacently and feel that because considerable progress in elevating production, increasing productivity and maintaining a reasonably high level of consumption had been achieved, the West were necessarily, in relative terms, at the 1947-1950 rates of industrial expansion, gaining with respect to the Kremlin dominated areas. " We should like to think that we are now gaining " he said, " and we may be ; but we must not minimise the other fellow's possible gains, both in production and techniques. The USSR'S MIG jet aeroplanes appear to be an example."

In addition, if figures such as were mentioned were indicative of merely orders of magnitude or trends, the USSR to-day would appear in many ways to have far greater material resources to call upon than had Germany at the outbreak of World War II. In steel, electric power and oil production, and in total population, the USSR would appear to have reached in 1950 higher levels than had Germany in 1939. Whereas the weight of Russia's backwardness might still press down the averages expressed on a *per capita* basis, " we must not be deluded into thinking that with the material and manpower resources at her command, with the ruthless power

of the central government to direct the devotion of these resources to its purpose if it so desires, and with the ability to call upon the services, voluntary or involuntary, of its own scientists and technologists and those of Eastern Germany and Czechoslavokia who are now behind the iron curtain, we can sit back and be complacent, or feel that through planning to assume certain added burdens we have already rectified the balance and tilted the scales definitely in our favour."

POTENTIALITIES IN THE WEST

The West in general, and the NATO countries in particular, had a high ceiling of potentialities, much higher than the Soviets and their satellites, and the dynamic elements of their economies could be increased. That would not, however, happen at a sufficiently rapid rate, and it required the application of brains, enterprise, courage, hard work and purposeful intent. How to do it, particularly to maintain a continuing socially and economically balanced increase of production at a competitive rate, both for its advantages in defence and likewise because of the hope which it offered for greater satisfaction from life in the pursuit of peace, afforded a great opportunity to Production Engineers.

The aggregate amount of capacity in assembly and finishing operations of manufacturing plants in the industrialised countries such as the United Kingdom, United States and likewise in Western Europe, at present exceeded the ability of the economies to supply the raw materials, labour and power to the system to utilise them fully. Bottlenecks had arisen and there had been a world shortfall in connection with raw materials ; but in all those items, except perhaps coal, within the NATO system of countries as a whole, the total availability far exceeded what it was before the war, and in 1951 even exceeded what it was in 1950.

It was not through reduction of supplies that the shortfall had taken place, but through increased total demand, civilian and military. For example, to take steel as an individual item, the aggregate production rate of crude steel in the NATO and OEEC countries as a whole at mid-year 1951 was at an annual rate approximately double that of those same areas in 1938. Exceeding 150 million metric tons, the mid-1951 rate was over 10 million tons higher than the actual output rate in 1950. The distribution, however, by individual countries and users was, of course, significantly different ; and whereas the rate of crude steel production in certain continental European countries and in the United States had increased in 1951 over 1950, in certain countries, for example the United Kingdom, due to the scrap situation, etc. there would appear to have been a decrease.

But in all those countries total demand had increased and at an

even faster pace than aggregate supply resulting in the shortfall. That naturally brought up for consideration the question of allocations and controls for the immediate future, internationally and domestically in certain countries, to determine the equitable sharing and most advantageous use of scarce resources. Allocations and some measure of control as to end use of various materials would appear to be essential just now, hence the International Materials Conference and the various commodity committees. But the long-term solution did not lie in the higher development of techniques of allocation. It lay in positive action to develop a wider availability of the basic materials which meant action at the source of raw materials.

THE PLACE OF THE PRODUCTION ENGINEER If NATO's objective of preserving peace was achieved, concluded Mr. Herod, then in the third phase and following years if the expansion of economy was continued, output should be adequate not only for the maintenance of armaments, but also for a progressively increasing flow of goods and benefits for civilian life. In the attainment of those the Production Engineer was a central figure. " In this great task the English speaking peoples have a rare opportunity. In material resources, in enterprise, in technical achievement they lead. In respect for law and the dignity of man they are second to none ; and with a common heritage of tradition, institutions, language and ideals, they can and must pull together and jointly supply leadership and indicate the path to a brighter future for all." (*Prolonged applause*).

Presentation of Institution Awards

The following awards were then presented by the President, the recipients afterwards being congratulated by Mr. Herod :—

The Institution Medal for the Best Paper presented by a Non-Member during the year 1949-50, to Mr. C. S. Johnson for his paper entitled " Modern Foundry Practice."

The Institution Medal for the Best Paper presented by a Member during the year 1949-50 to Mr. J. S. Paget, M.I.Prod.E., for his paper entitled " Works Organisation for Research and Development of Aircraft Engines."

The Lord Austin Prize 1950 for the Best Essay by a Graduate to Mr. G. N. Johnson, Grad.I.Prod.E., for his essay entitled " Production Economy in Aircraft Manufacture."

The Hutchinson Memorial Award for the Best Paper presented by a Graduate during the year 1949-50 to Mr. H. G. Bottomley, Grad.I.Prod.E., for his paper entitled " Recent Developments of Production Grinding Machines."

The Schofield Travel Scholarships 1951 were won by Mr. A H.. Needham, Grad.I.Prod.E., and Mr. F. W. Walton, Grad.I.Prod.E., both of whom were unable to receive their certificates owing to absence abroad on their Scholarship projects.

"The Guests"

MR. HAROLD BURKE, the Vice-Chairman of Council, who proposed the toast of the Guests, said that the list of guests covered "several foolscap sheets" and it was therefore a little difficult to mention them all by name.

However, briefly referring to a few of the distinguished visitors present, Mr. Burke mentioned Mr. A. C. Hartley, C.B.E., President of the Institution of Mechanical Engineers, and Mr. B. G. Robbins, M.Sc., the Secretary ; Sir John Hacking, the President Elect, the Institution of Electrical Engineers ; Mr. H. J. Furness, representing the President of the Institute of Cost and Works Accountants ; Sir Percy Mills, K.B.E., President, Institute of Industrial Supervisors ; Mr. T. Padmore, C.B., Secretary to the Cabinet ; Sir Greville Maginness, Joint Chairman, Anglo-American Council on Productivity ; Sir Thomas Hutton, K.C.I.E., C.B., M.C., General Manager, Anglo-American Council on Productivity ; Mr. H. A. R. Binney, C.B., Director, British Standards Institution ; Sir Archibald Forbes, President, Federation of British Industries ; Mr. R. W. Asquith, President, Machine Tool Trades Association, and Mr. W. J. Morgan, M.B.E., the General Manager ; The Hon. R. A. Balfour, President, National Federation of Engineers' Tool Manufacturers ; Mr. G. T. Beach, Secretary, Gauge & Toolmakers' Association ; Mr. F. Bray, C.B., Under-Secretary, Ministry of Education ; Sir Godfrey Ince, G.C.B., K.B.E., Permanent Secretary, Ministry of Labour and National Service ; Sir Archibald Rowlands, G.C.B., M.B.E., Permanent Secretary, Ministry of Supply, and Sir Cecil Weir, K.B.E., M.C., D.L., lately Chairman of the Dollar Exports Board.

Response by Sir Cecil Weir

SIR CECIL WEIR, K.B.E., M.C., D.L., in a brief response on behalf of the guests, thanked Mr. Burke for his warm welcome and the Institution for the excellent hospitality which had been extended to the guests. He also congratulated the Institution on the high honour it had received in the selection of the Chairman of Council, Mr. Puckey, to be Deputy Controller of Supplies (Air) in the Ministry of Supply.

The President announced the impending departure for another country of MR. BARRY T. BENSON, the U.S. Commercial Attaché.

In response to the President's invitation to say a few words in connection with the " American Commercial Attaché's Award " to the Institution, Mr. Benson said that the idea of such an award was conceived by Sir Frederick Bain. Sir Frederick had said to him ; " I know how you feel about productivity and how you feel towards the Institution of Production Engineers. Could you not consider an award ?" and that was why a Production Engineers' Cup was being presented to the Institution. The Cup would be passed on from year to year as might be determined and " I hope that it will be an inspiration to young engineers and young men of productivity " concluded Mr. Benson " to produce more that we may have a better life and security in the future." (*Applause*).

Notes

Notes

INSTITUTION AWARDS

Lord Austin Prize

This prize consisting of books and/or instruments together with a certificate, is presented annually for the best Essay submitted by a Graduate of the Institution. Details of conditions are published in the Journal each year.

Hutchinson Memorial Medal

A medal is awarded annually for the best paper presented to a Section by a Graduate of the Institution.

Institution Medals

Silver medals are awarded each year for the best paper presented to a Section during the year by (a) a member, and (b) a non-member.

Schofield Travel Scholarships

The Scholarships provide for two Graduates each year to spend six months on industrial study visits in selected overseas countries. Details and conditions of the Award are published each year in the Institution's Journal.

ANGLO-AMERICAN COUNCIL ON PRODUCTIVITY

SPECIALIST TEAM REPORTS

Materials Handling	2/6
Simplification in Industry	1/-
Simplification in British Industry	1/-
Packaging	2/6
Management Accounting	2/-
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PRODUCTIVITY TEAM REPORTS

Steel Founding	3/-
Cotton Spinning	3/-
Cotton Doubling	3/-
Cotton Weaving	2/-
Building	2/6
Internal Combustion Engines	2/6
Pressed Metals (Deep drawn)	2/6
Clothing (Men's outwear)	3/-
Fertilizers (Superphosphate and Compound)	3/-
Electric Motor Control and Switch Gear	2/-
Grey Ironfounding	3/6
Electricity Supply	3/6
Diesel Locomotives	3/-

These Reports may be obtained from the Offices of the Council, 21, Tothill Street, London, S.W.1.

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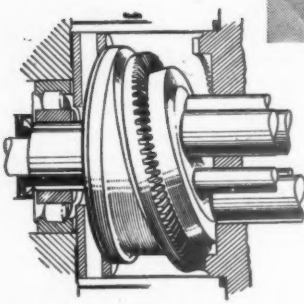
AXIAL PLUNGER PUMPS

THE PUMP WITH THE GEARED WOBBLER



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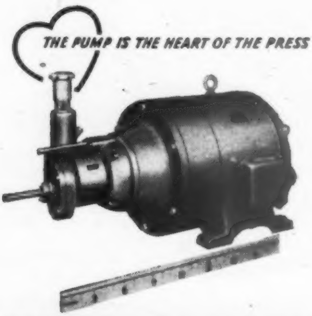

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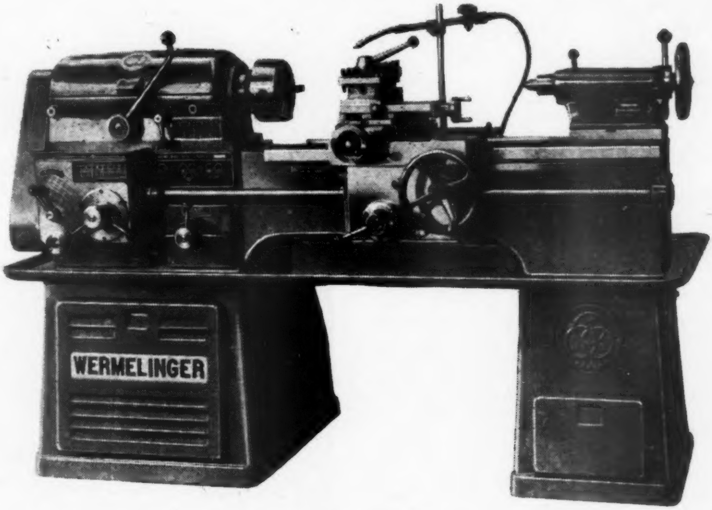
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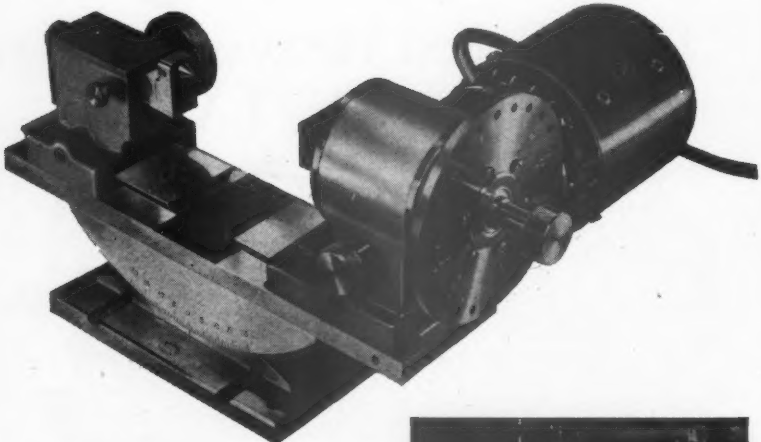

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The spindle is mounted on precision preloaded ball bearings and has a work speed of 185 R.P.M. Angular settings are obtained either by adjusting the swivel base or utilising the two .250 dia. Jig ground holes 10.000" apart, thus forming a 10" sine bar, whilst Rotary Indexing is obtained by means of the index plate provided. Components can either be mounted on the faceplate, between centres or held in a collet up to ½" dia.

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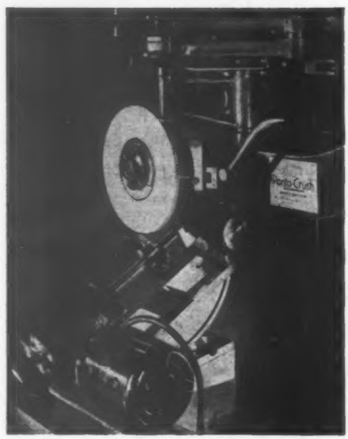

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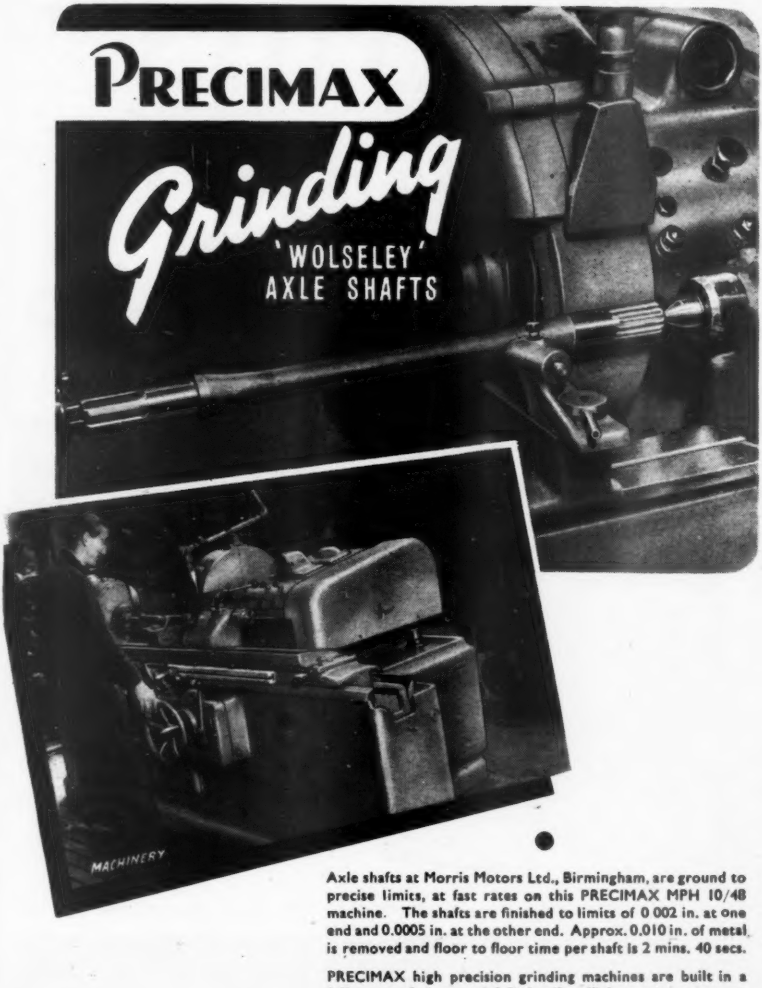
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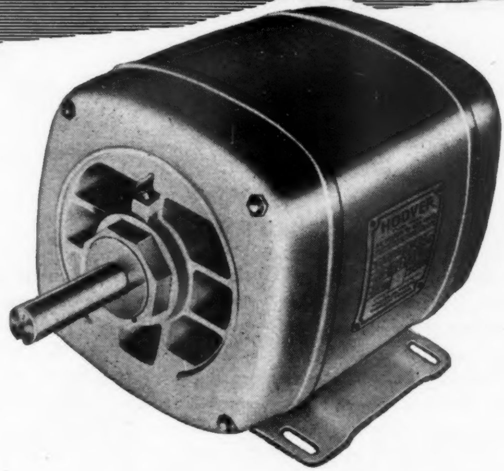
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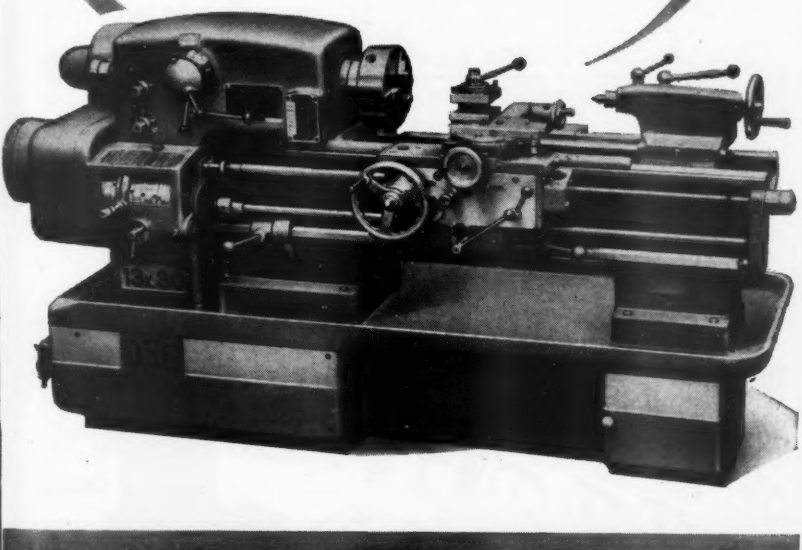

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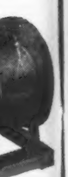

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